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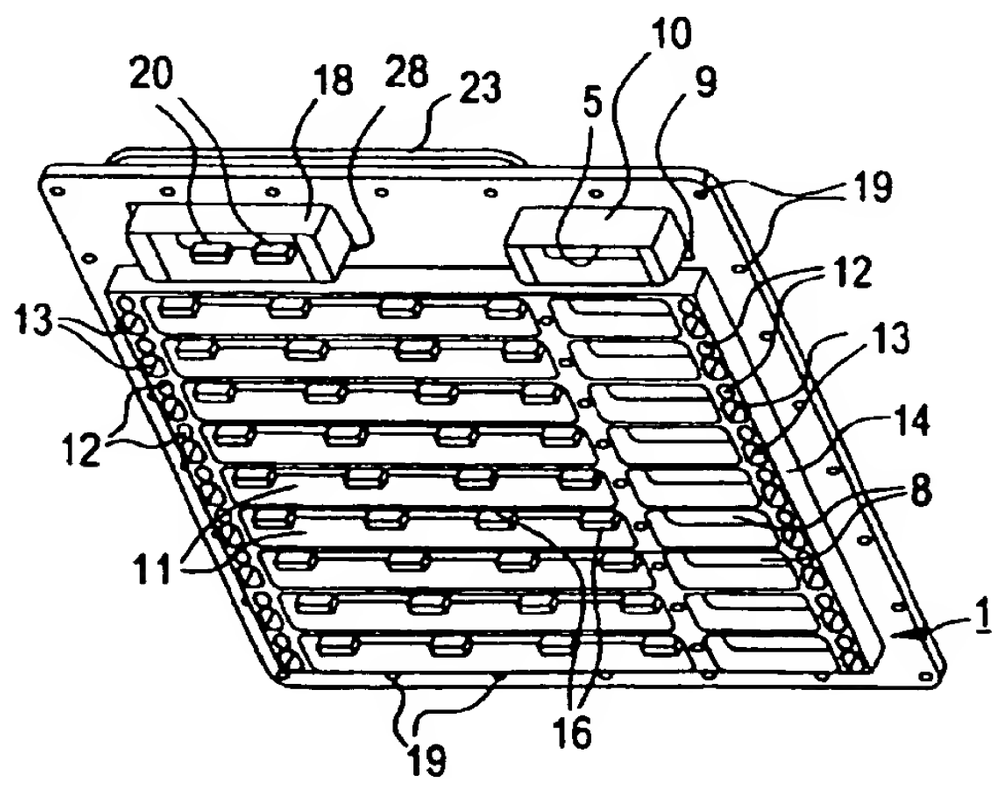
(54) Modular optical/electronic backplane assembly

(57) A backplane assembly for a line replaceable module enclosure or rack includes an electrical backplane and a fiber optic backplane separately attachable to a single frame. The frame serves as a common datum for the electrical and fiber optic backplanes, and includes integral mating interface features for enabling line replaceable module connectors having a common shell to mate with the separate electrical and fiber optic connector structures on the backplane. The optical backplane is a one-piece structure to which pairs of individual fiber optic connectors, including input/output connectors, may be directly secured via a simple retention plate arrangement, the fiber optic connectors all having the same orientation to enable direct routing of fiber ribbons between rows of connectors serving different line replaceable modules.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This invention relates to a modular backpanel interconnect system capable of providing optical and electrical interconnections between components housed within an integrated rack, as well as input/output connections and rack-to-rack interconnections. The invention is particular suited for, though not limited to, military avionics applications such as the proposed "optical backplane interconnect system" (OBIS).

2. Discussion of Related Art

[0002] The type of backplane with which the present invention is concerned typically extends along the back surface of an enclosure or integrated rack of the type used in avionics systems. The rack supports electronic components which plug into the backplane from the front and provides interconnections between the components as well as input/output connections to control systems in the airplane and rack-to-rack interconnections, and is designed to facilitate removal and replacement of components with a minimum of downtime, thereby significantly improving flight readiness.

[0003] Each of the components performs a control, sensing, or recording function and is typically in the form of a circuit card utilizing very high speed integrated circuitry (VHSIC) technology contained within a sealed metal housing to form a package known as a line replaceable module (LRM). Descriptions of line replaceable modules and integrated racks therefor are found U. S. Patent Nos. 4,308,115 and 5,234,348.

[0004] While systems employing purely electrical line replaceable modules have been employed in military avionics for many years, current development has concentrated on the integration of optical interfaces into the modules. Optical interfaces provide higher bandwidth connections than is possible with purely electrical interconnections, and may be used in connection with such functions as multi-sensor integration, data fusion, image processing, and Automatic Target Recognition.

[0005] The present invention is part of that effort, but concerns the backplane into which the modules are plugged rather than the modules themselves, or the connectors which are provided on the modules. It was developed in connection with a program known as the optical backpanel interconnect system (OBIS), whose objective is to provide a compact and easily serviceable backpanel assembly for use in connection with line replaceable modules having different data rates and protocols, with data rate and communication restrictions imposed by the optical backplane being limited only by the capability of the passive optical interconnections, the switching functions being provided by one of the line replaceable modules, known as the fabric module, so that the backplane can be used to interconnect a variety of different functional elements simply by appropriately designing the fabric module.

[0006] Although the present invention is designed to meet the OBIS specifications, it is not limited thereto, and features of the invention will have applicability to component rack systems used in fields other than military avionics, such as the next generation of commercial aircraft, including systems other than those employing line replaceable modules. However, unlike prior purely optical fiber optic connector modules or patch panels of the type commonly used in other industries, such as the telecommunications industry, the OBIS-type systems with which the present invention is concerned must meet rigid space and reliability requirements, and must share the space with electrical power lines, which are necessary to provide power, ground, and low speed control lines, as well as to permit backward compatibility. As a result, prior optical interconnect systems offer few solutions to the problems addressed by the present invention, and are cited here primarily as background. Examples of such prior purely optical interconnect systems, primarily for use in telecommunications type optical connector modules, are found in U.S. Patent Nos. 5,513,293, 5,412,497, 5,363,465, and 5,204,929. Also of interest as background are prior optical interconnect systems which also include electrical connectors, including the above-cited U.S. Patent No. 4,808,115 which describes a line replaceable module connector including optical and electronic connections, but not a modular backplane, U.S. Patent Nos. 5,037,313 and 5,611,013, which also describe opto-electronic connectors but not in connection with either a line replaceable module or a rack system, and U.S. Patent No. 5,486,113, which is representative of a number of references describing purely electrical backplanes designed to provide purely electrical connections between components having different requirements. None of the connectors or interconnection systems described in these patents is suitable for use in the OBIS system, or in general to provide a modular interconnect system having the combination of compactness, reliability, and ease-of-maintenance of the present invention.

[0007] Instead, despite the sophistication and rapid development of components requiring optical interconnects, the experience of the telecommunications industry, and even the previous incorporation of optical connectors in LRM interconnect systems represented by the system described in U.S. Patent No. 4,808,115, initial attempts at meeting specifications for optical interconnect systems have approached the problem as one of simply retrofitting optical connectors onto conventional electrical backplanes. For example, one proposed design involves mounting of individual optical connectors in a common frame to form a modular optical backplane, the optical backplane in turn being mounted behind an essentially conventional electrical backplane so that it

can be separately removed for repair and maintenance.

[0008] While this arrangement facilitates the inclusion of optical connectors in the backplane, it has a number of disadvantages. For example, in order to service the electrical backplane, the optical backplane must be removed even if the optical backplane does not need servicing. In addition, this design does not provide an input/output connector for simplifying external fiber optic connections to the backplane, as opposed to interconnections between modules forcing each separate connector on the module to be disconnected in order to remove the module, and because the previously proposed optical backplane design is simply piggybacked onto a standard electrical backpanel arrangement, the fiber optic interconnects must be routed around the central electrical connections using a T formation of the fiber ribbons in order to optimize in plane versus out of plane bends.

[0009] The present invention, in contrast, abandons any attempt to fit the optical backplane onto the standard electrical backplane, taking the unique approach of designing the electrical and optical elements of the backplane as separate modules, while still integrating the modules to form a common backplane which possesses the necessary dimensions, permits use of the backplane in an otherwise standard LRM rack, meets reliability standards critical for military and other avionics applications and yet is more efficient to manufacture than previously proposed designs.

SUMMARY OF THE INVENTION

[0010] It is accordingly an objective the invention to provide a modular backplane assembly having both electrical and fiber optic connector modules for providing electrical and optical connections between electronic components, and in which the electrical and fiber optic connector modules are independently separable from the backplane assembly for service or replacement.

[0011] It is also an objective of the invention to provide a modular backplane assembly which provides connectorized input/output as well as module-to-module interconnections, simplifying both the replacement of components within the rack and external connections to the backplane.

[0012] It is another objective of the invention to provide a modular backplane assembly having an optical connector module in which all slots possess the same orientation, eliminating the need for T formation routing of the fiber optic interconnection ribbon cables.

[0013] It is yet another objective of the invention to provide a modular backplane assembly having an optical connector module which permits direct routing of all fiber interconnects.

[0014] It is a further objective of the invention to provide a modular backplane assembly having an increased connector density.

[0015] It is a still further objective of the invention to provide a modular backplane assembly having a common shell or frame for the electrical and optical connector modules that provides a common datum for each module and the rack, and which reduces tolerance stack-up.

[0016] It is also an objective of the invention to provide an arrangement for applying a bias to fiber optic connectors which occupies a relatively small volume and yet provides a high spring force without plastic deformation of the springs.

[0017] These objectives are achieved, in accordance with the principles of a preferred embodiment of the invention, by providing a backplane assembly made up of an electrical backplane and fiber optic backplane separately attachable to a single frame, the single frame serving as a common datum for the electrical and fiber optic backplanes. Preferably the single frame includes integral mating interface features for enabling line replaceable module connectors having a common shell to mate with the separate electrical and fiber optic connector structures on the backplane.

[0018] Also in accordance with the principles of the preferred embodiment of the invention, the optical backplane is a one-piece structure to which pairs of individual fiber optic connectors, including input/output connectors, are directly secured via a simple retention plate arrangement, the fiber optic connectors all having the same orientation to enable direct routing of fiber ribbons between rows of connectors serving different line replaceable modules.

[0019] The electrical backplane of the preferred embodiment is essentially standard, but provides a reduced number of electrical connections in recognition of the decreased need for such connections afforded by the use of high speed optical interconnects, thereby making available sufficient space to arrange the optical backplane in a rectangular configuration which permits the optical connectors to all have the same orientation, and which permits direct routing between the optical connectors and connectors on a fabric module.

[0020] Because the optical connectors all have the same orientation and arranged in horizontal rows, they can be used with line replaceable module connectors containing both electrical and fiber optic components fitted within a standard SEM-E shell, in a manner similar to that disclosed in U.S. Patent No. 4,808,115, but with increased number of fiber optic connections per shell. An especially advantageous version of the standard SEM-E shell is disclosed for use in connection with the backplane of the present invention, although the shell itself is not part of the present invention.

[0021] In addition, an especially advantageous arrangement for biasing the individual fiber optic connectors towards each other is disclosed, in which both the backplane and the corresponding connectors include provision for accommodating stacked leaf spring arrangements which permit a high biasing force to be generated in a relative small space without plastic deformation of the springs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Figure 1 is a perspective view of the front of a modular backplane assembly constructed in accordance with the principles of a preferred embodiment of the invention.

[0023] Figure 2 is an exploded perspective view of the front of the modular backplane assembly of Figure 1.

[0024] Figure 3 is a perspective view of the rear of the modular backplane assembly of the preferred embodiment.

[0025] Figure 4 is an exploded perspective view of the rear of the modular backplane assembly of Figure 3.

[0026] Figure 5 is a cross-sectional side view of the optical backplane subassembly shown in Figures 1-4.

[0027] Figure 6A is a perspective view of the optical backplane sub-assembly of the preferred embodiment of the invention.

[0028] Figure 6B is a further perspective view of the optical backplane sub-assembly of the preferred embodiment of the invention.

[0029] Figure 7A is a plan view of an alternative fiber optic backplane configuration according to the principles of a preferred embodiment of the invention.

[0030] Figure 7B is a plan view of an alternative common frame for the fiber optic backplane illustrated in Figure 7A.

[0031] Figure 7C is a schematic of a direct ribbon cable routing configuration which can be used with the optical backplane of the preferred embodiment.

[0032] Figure 8 is a plan view of a connector for use in connection with the backpiane of the preferred embodiment.

[0033] Figure 9 is a front view of the connector of Figure 8.

[0034] Figure 10 is a partially cross-sectional side view taken at location IX in Figure 8.

[0035] Figure 11 is a cross-sectional side view taken along line X-X in Figure 8.

[0036] Figure 12 is a cross-sectional side view taken along line XI-XI in Figure 8. .

[0037] Figure 13 is a bottom plan view of the portion of the connector shown in cross-section in Figure 12.

[0038] Figure 14 is a cross-sectional side view similar to that of Figure 10, but including a heatsink and circuit boards.

[0039] Figure 15 is a perspective view showing the front of an optical insert for the connector of Figures 8-12.

[0040] Figure 16 is a perspective view showing the rear of an optical insert for the connector of Figures 8-12.

[0041] Figure 17 is a perspective view of an optical connector module for the insert of Figures 13 and 14.

[0042] Figure 18 is a cross-sectional side view of the optical connector module illustrated in Figure 17.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0043] As illustrated in Figures 1-4, the backplane assembly of the preferred embodiment of the invention includes a frame 1, an electrical backplane 2, and a fiber optic backplane 3. The frame 1 serves as a common datum for the electrical and fiber optic backplanes, but each of the backplanes is separately attachable and removable from the frame for service or replacement.

[0044] Frame 1 and backplanes 2 and 3 are one-piece structures and, although not limited to a particular material, are preferably made of a conductive metal such as nickel-plated aluminum alloy to provide grounding capabilities as well as structural support for the electrical and optical connectors. with the materials of the backplanes preferably being matched to each other and to the rack in which the backplanes are accommodated to compensate for thermal expansion.

[0045] Electrical backplane 2 is essentially a flat plate having a plurality of openings (not shown) for receiving multiple contact electrical connector inserts 4, and an opening 5 for receiving an input/output connector insert (not shown). In addition, electrical backplane 2 includes a plurality of holes 6 corresponding to threaded holes 7 in the frame 1, and through which screws or other suitable fastening means may be inserted to secure the electrical backplane to the frame (holes 7 are shown only in Figures 3 and 4).

[0046] To permit access to the electrical connector inserts 4 from the front of the backplane assembly, frame 1 includes openings 8 and 9 shaped to receive the front of inserts 4 and a shielding structure 10 extending forwardly of the input/output connector opening 5 on electrical backplane 2. Also included in frame 1 are a plurality of openings 11 for receiving forwardly extending portions 15 of the optical backplane 3, described below, fiber optic input/output connector opening 28, and holes 19 for attaching the frame to a rack or line replaceable module enclosure.

[0047] The portion of frame 1 surrounding openings 8, 9, and 11 is in the form of a mating interface structure 14 projecting from the frame to provide shielding for the connector inserts and which, as illustrated, includes threaded openings 12 and key-receiving openings 13 corresponding to openings in the SEM-E backplane connectors illustrated in Figures 8-14, which serve as connectors for the line replaceable modules with which the illustrated backplane assembly is designed to be used. Openings 12 and 13 are arranged to receive the standard fastening screw and keying features provided on the corresponding line replaceable module connectors.

[0048] It is of course possible to vary the shapes of the insert-receiving openings in the electrical backplane 2 and frame 1 to accommodate different types of connector inserts, and different mating interface configurations, as well as to fasten the electrical backplane to the

frame by means other than screws or other discrete fasteners, the invention not being limited to SEM-E connectors or to any particular fastening arrangement. In addition, the area occupied by the electrical connector backplane relative to the frame may be varied depending on the ratio of optical to electrical interconnections desired, although the illustrated embodiment is notable in that it devotes only approximately 33% of the space for electrical pins, with the rest of the space being for optical connectors. This is a significant difference from prior designs, and results from the fact that high speed data communication is now primarily optical, with the electrical portion only requiring power, ground, and a few low speed control lines, with the structure and arrangement of the contacts in the inserts, and of the inserts themselves, being otherwise standard.

[0049] On the other hand, the placement of the threaded openings 12 on a forwardly extending portion of the frame rather than on a forwardly extending portion of the backplane, although not absolutely necessary, is particularly advantageous because it allows the electrical backplane to be detached without first detaching the line replaceable modules from the frame, and the inclusion of shield and other mating interface structures on the frame rather than the backplane being advantageous in order present a continuous mating interface to both the electrical and optical sides of the mating connectors, without alignment problems such as might occur if the critical mating structures were divided between the separate backplanes.

[0050] While the electrical backplane 2 accommodates high density connector inserts which are essentially standard except for the reduced size of the inserts resulting from the recognition that a smaller number of electrical connections are required in the OBIS design, the fiber optic backplane is unique in that it does not use discrete fiber optic connector supporting structures or modules, the fiber optic connectors 16 instead being secured directly to the fiber optic backplane itself. To this end, the fiber optic backplane 3, which is shown in greater detail in Figures 5, 6A, and 6B includes a plurality of integral raised portions 15 having individual openings 17 for receiving the plurality of fiber optic connectors 16, as will be explained in more detail below, the raised portions 15 being received, as indicated above, in openings 11 of the frame 1. In addition, the illustrated fiber optic backplane 3 includes a raised portion 18 surrounding openings (not shown) for at least two input/output fiber optic connectors 20.

[0051] The fiber optic backplane 3 is attached to the frame 1 in a manner similar to the manner in which the electrical backplane is attached. For example, holes 21 in the fiber optic backplane may be aligned with holes 22 in frame 1 (holes 22 are shown only in Figures 3 and 4) to receive screws or other attachment means by which the fiber optic backplane is secured to the frame from the rear when raised portions 15 of the fiber optic backplane are fitted into openings 11 in the frame, or other attachment means may be provided as desired. In addition, the fiber optic backplane 3 may be fitted with a cover 23 once the connectors 15 and 20 have been secured thereto.

[0052] Because the electrical and fiber optic connectors are positioned side-by-side, as is best seen in Figures 3 and 4, either of the backplanes can be removed for repair or replacement without affecting the other. In order to minimize the space occupied by the two backplanes, the adjoining edges may include complementary extensions 24 and 25 containing the respective attachment holes 6 and 21, so that the portion 26 of frame 1 situated between openings 8 and 11 and containing threaded holes 7 and 22 may be minimized. In addition, threaded holes 7 and 22 may simply be replaced by slots, each of which is capable of accommodating a pair of screws or bolts, which would allow for some tolerance in the fit between the extensions. This is desirable because, in the illustrated embodiment, the fiber optic connectors and electrical contacts of the mating line replaceable modules are contained in common shells, as illustrated in Figures 8-14, and therefore precise vertical alignment between the optical and electrical backplanes is therefore necessary.

[0053] In addition to the possible variations noted above, those skilled in the art will appreciate that the number and relative locations of the input/output connectors openings may be varied as required, as may the locations of the screw holes for fastening the respective backplanes to the frame. Furthermore, the input/output connectors may be omitted from the backplane assembly entirely in favor of direct cable connections to selected fiber optic connectors and/or electrical connector inserts as necessary.

[0054] One such alternative configuration is shown in Figures 7A and 7B, in which the location of the fiber optic input/output connectors 20 for the fiber optic backplane 3 is moved from the top left side of the backplane to the bottom center position, and the opening 9 for the electrical input/output connector structure is expanded and place below the fiber optic input output connectors. Although not shown, in this variation the electrical backplane can either assume an L-shape, or the electrical input/output connector can be a separate structure. Since the backplanes and frame of this variation are otherwise essentially identical to the backplanes and frame of Figures 1-5, 6A, and 6B, except for the positions and size of the input/output connector openings, and except that holes 27 on the fiber optic backplane 3 for receiving cover mounting screws are illustrated, elements of this variation have been given the same reference numerals as corresponding elements of the first illustrated embodiment.

[0055] In the illustrated embodiment, fiber optic connectors 16 are in the form of twelve fiber connectors of the type known as MT connectors, which include a mating portion 30, alignment pins 30', pin block 31, and strain relief 32, from which extends cable 33. These con-

nectors are standard and form no part of the present invention and it is in any case within the scope of the invention to use fiber optic connectors other than the illustrated MT connectors, and to vary the shapes of the connector receiving openings 17 accordingly.

[0056] As illustrated in Figures 5, 6A, and 6B, openings 17 advantageously communicate with a common opening 34 for a pair of connectors, with the front surface 35 of the common opening providing a datum for the front surfaces of the connector pin blocks, and the common opening 34 being further in communication with a common groove 36 for a row of connector pairs, the front surface 37 of the common groove including threaded openings 38 for screws (not shown) used to attach retaining plates 39. Retaining plates 39 include screw holes 40 and slots 41 for providing passage of cables 33, and are used to retain the fiber optic connectors in the openings 34. Biasing of the connectors in a forward direction is provided by a spring arrangement which presses against the rear of the connectors, illustrated as being provided with pin clamps 42, with the grooves 36 being separated from each other by structures 45 which form cable support rails, illustrated in Fig. 6B.

[0057] In particular, in the illustrated embodiment, the plates 39 include cavities 43 in which are placed springs 44 so as to engage the rear of the pin clamps 42 and press the connectors in the forward direction, and the springs 44 are in the form of simple curved beam springs which are stacked and fitted in a stressed condition within cavities 43, four to a cavity. Stacking of the simple curved beam springs permits a greater force to be generated over a small range of displacement than is possible with a single spring, which has been found to create a large spring force in a very small volume without plastic deformation. A spring of the equivalent thickness would plastically deform at a much lower deflection than the stack of four.

[0058] This simple retention arrangement minimizes the number of parts required, ensures accurate alignment of the connectors, provides excellent shielding, and yet increases connector density because the need for discrete connector housing modules is eliminated. Furthermore, it can be used either to removably retain the fiber optic connectors within the fiber optic backplane for the life of the connectors, or to removably retain the connectors on a temporary basis during testing, with permanent retention being obtained by filling grooves 36 with a potting material once assembly and testing has been completed.

[0059] The ribbon cables 33 extending from the rear of the connectors can either be connected directly to components external to the rack, to the fiber optic input/output connector for facilitating interconnection between racks and other components, or to other modules. It is of course anticipated that many of the connectors will not be used since the basis of the OBIS design is to provide sufficient connectors for a variety of different rack and component arrangements. As indicated above, however, one of the advantages of the preferred embodiment of the invention, and in particular the manner in which the fiber optic connectors are arranged, is that direct routing of interconnect cables between the connectors is possible, as illustrated by way of example in Figure 7C, in which the center row of connector pairs 43 is arranged to serve as the fabric module connection for providing switching functions between the other modules 44 and is connected to the other modules by direct routing of the twelve channel multimode ribbon cables 33 to the appropriate connectors 16. It will be appreciatec by those skilled in the art that the preferred backplane assembly also lends itself to numerous other cable routing configurations, and that even the arrangement of fiber optic connectors in rows of pairs may be varied within the scope of the invention. Because the MT connectors are all oriented in the same direction, there is no need to bend the fibers, providing a continuous low loss optical pathway between each of the modules.

[0060] While the electrical and fiber optic backplane modules of the preferred embodiment may be designed, within the scope of the invention, for use with a variety of different line replaceable module connectors, and for use with mating connectors other than those used in line replaceable modules, including mating connector arrangements in which the electrical and fiber optic connectors are separate structures, an especially advantage line replaceable module connector is one in which the optical and electrical connector components are integrated into a single shell, illustrated in Figures 8-14 as an SEM-E shell. The overall size and shape of the shell, the configuration of the electrical connector side of the shell, and the attachment and keying features are all standardized or conventional, with the two differences between the illustrated SEM-E shell and known SEM-E shell configurations being the arrangement of the fiber optic connectors in the shell, and the relatively small area occupied by the electrical connector side of the shell, which area corresponds to the area of the electrical portion of the backplane assembly of the preferred embodiment.

[0061] The illustrated line replaceable module connector 50 is arranged to mate with one of the electrical connector inserts 4 in the electrical backplane 2, and with a row of fiber optic connector pairs in the iber optic backplane 3, and includes a common shell 51 having an opening for receiving an electrical connector insert 52 and an opening for receiving a single fiber optic connector insert 53, the optical connector insert 53 in turn having a plurality of openings for receiving optical connector modules 54, each of which supports two fiber optic connectors 55 corresponding to the fiber optic connectors 16 of the preferred backplane assembly.

[0062] The common shell 51 for the electrical and fiber optic connector inserts actually consists upper and lower halves 56 and 57 which are secured at the rear

via rearwardly extending tower assemblies 58-60 on the upper half 56, and rearwardly extending tower assemblies 61-63 on the lower half, as is best shown in Figures 10. 12. and 14. Each of upper tower assemblies 58-60 includes a through hole 64 corresponding to a threaded hole in lower tower assemblies 61-62, with a space 79 being formed between the upper and lower tower assemblies for receiving a forward portion of a heat sink 80 on the line replaceable module circuit card, the upper and lower tower assemblies and heat sink being secured together by screws 81 extending through holes 64, the heat sink, and threaded holes 65. Lower tower assemblies 61 and 63 at the ends of the line replaceable module connector shell 50 may include bosses 66 arranged to fit through alignment openings in the heat sink. As is conventional. additional screw holes 67 for receiving screws 82 are provided in both the upper and lower tower assemblies 58-60 and 61-63 to attach cover plates 68 for the upper and lower sides of the module.

[0063] The contact assemblies of the electrical connector insert are conventional. As shown in Figure 11, the contact pins 83 include radiused, surface mount tails 84 extending rearwardly from the mating portions 85 (shown in Figures 8 and 9) of the contact pins, with a tab 86 being provided at the end of the respective upper and lower contact tails for maintaining alignment between the contact tails prior to soldering of the contact tails to the circuit boards 87 and 88 of the line replaceable module.

[0064] The ends of the front side of the upper and lower shell halves 56 and 57 include, respectively, keying features 89 and connector attachment screws 90, details of which may be found in the PCT application WO 98/31075 published on July 16, 1998 , and which are arranged to cooperated with the corresponding holes 12 and openings 13 on frame 1 of the preferred backplane assembly. These features are standard and form no part of the present invention.

[0065] Both the electrical connector insert 52 and fiber optic connector insert 53 are surrounded by shields, respectively numbered as elements 69 and 70, which have a conventional configuration and are arranged to engage the walls of openings 8 and 11 in raised portion 14 of frame 1 of the backplane assembly of the preferred embodiment. While the shields 69 and 70 may be captured and secured between shell halves 56 and 57 by any of a variety of known arrangements, in the illustrated embodiment capture is achieved by means of flanges 71 on respective downwardly and upwardly extending portions 72-74 and 75-77 situated at the front of the upper and lower halves forwardly of tower portions 58-60 and 61-62. Flanges 71 cooperate with flanges 78 on the respective shields to capture the shields when the upper and lower halves are assembled together in a manner similar to that described in copending U.S. Patent Application Ser. No. 08/782,792. cited above. and illustrated in Figure 13.

[0066] Turning to Figures 15-18, the fiber optic connector insert 53 of the illustrated line replaceable module connector for use with the preferred backplane assembly includes openings 91 for each of the plurality of dual fiber optic connector modules 54. with each module 54 including a pair of openings 92 for receiving the individual connectors 55. The connector modules each includes a front portion 93 for aligning the mating portions 94 of connectors 55 with corresponding mating portions of connectors 16 on the backplane assembly. and a rear pin block portion 95 which cooperates with pin block portions 96 of the individual connectors 55 and with surface 97 at the rear of the connector insert openings 91 to define the axial positions of the respective connectors and modules. The pin block portions 96 of the individual connectors are secured in the modules and biased forwardly by retention springs 98 which are fitted into openings 99 of caps 100.

[0067] Preferably. the retention springs 98 are in the form of a leaf arrangement made of four simple curved beam springs stacked in each opening 99. As was the case for the optical backplane assembly described in connection with Figs. 5 and 6, stacking of the simple curved beam springs permits a greater force to be generated over a small range of displacement than is possible with a single spring, which has been found to create a large spring force in a very small volume without plastic deformation.

[0068] The ribbon cables 101 extending from the connectors via boots 101' exit the modules through end slots 102 in caps 100, caps 100 being secured to rear projections 103 of the fiber optic connector insert 53 by means of screw holes 104 in the projections 103, plates 105 containing openings 106, screws 107, and shoulders 107' on formed in the rear of caps 100. Finally, in the illustrated arrangement, the shield 70 for the fiber optic connector insert includes a separate front plate 108 secured to the insert by screws 109, slots 102 include a portion 102' extending around the side of the cap to facilitate assembly of the connectors into the inserts, and front portions 93 of the inserts include keyways 110 which cooperate with slots 111 in openings 91 in the fiber optic connector insert 53 to ensure proper orientation of the connector modules 54 with respect to the connector insert 53.

[0069] It will of course be appreciated that the details of the manner in which the electrical and fiber optic inserts are assembled and mounted in connector 50 can be freely varied without affecting the structure of the backplane assembly which constitutes the principle preferred embodiment of the invention. While aspects of the construction of connector 50 as described above may be particularly advantageous, it is intended that the invention not be limited by any of these details, which are included for illustrative purposes.

[0070] Thus, having described various preferred embodiments of the invention with sufficient particularity to enable those skilled in the art to make and use the invention, it should nevertheless be appreciated that var-

iations and modifications of the preferred embodiment not specifically described herein may be made without departing from the scope of the invention. Instead, it is intended that the invention not be limited by the above description or accompanying drawings, but that it be defined solely in accordance with the appended claims.

Claims

1. A backplane assembly, comprising:

   a frame having a plurality of first openings and a plurality of second openings;
   an electrical backplane including a plurality of electrical connector inserts arranged to fit through respective ones of said plurality of first openings, and means for attaching said electrical backplane to said frame;
   a fiber optic backplane including a plurality of individual connector openings for receiving individual fiber optic connectors, said fiber optic connectors being arranged in rows with at least one row of fiber optic connectors being received in said second openings of said frame, and means for attaching said fiber optic backplane to said frame.
   wherein said frame serves as a common datum for said electrical and fiber optic backplanes, and said electrical and fiber optic backplanes are separately removable from said frame.

2. An assembly as claimed in claim 1, wherein said electrical and fiber optic backplanes are attached to a rear side of said frame, and a front side of said frame includes mating interface features for engaging corresponding mating interface features of mating connectors containing both optical and electrical connector components.

3. An assembly as claimed in claim 2, wherein said mating interface features include means for receiving attachment screws extending from said mating connectors.

4. An assembly as claimed in claim 2, wherein said mating interface features include means for receiving keying features extending from said mating connectors.

5. An assembly as claimed in claim 2, wherein said mating interface features include means for providing shield continuity between said electrical and optical backplanes and said line replaceable module connectors.

6. An assembly as claimed in claim 2, wherein said mating connectors are connectors attached to line replaceable modules of a component rack system.

7. An assembly as claimed in claim 1, wherein said fiber optic connectors are secured to said fiber optic backplane by retention plates, each retention plate serving to retain a pair of said connectors within said individual connector openings.

8. An assembly as claimed in claim 7, wherein said retention plates include cavities arranged to accommodate biasing means for biasing said connectors in a mating direction.

9. An assembly as claimed in claim 8, wherein said biasing means comprises a retaining plate having a stack of curved beam springs bonded thereto, said retaining plate being assembled over fiber optic cables extending from said connectors and being retained in said cavities by said retention plates.

10. An assembly as claimed in claim 9, wherein said line replaceable module connectors also include means for biasing fiber optic connectors in a mating direction, said means for biasing fiber optic connectors of said line replaceable modules in said mating direction including springs comprising stacked curved beam springs.

11. An assembly as claimed in claim 1, wherein said fiber optic connectors all have the same orientation.

12. An assembly as claimed in claim 1, wherein said fiber optic connectors are MT connectors.

13. An assembly as claimed in claim 1, wherein said fiber optic backplane includes additional fiber optic connectors for facilitating fiber optic input/output connections to said rack.

14. An assembly as claimed in claim 1, wherein said electrical and fiber optic backplane attachment means are screws.

15. An assembly as claimed in claim 1, wherein said backplane assembly forms a backplane of a line replaceable module rack system, and said electrical backplane is substantially smaller than said fiber optic backplane.

FIG. 2

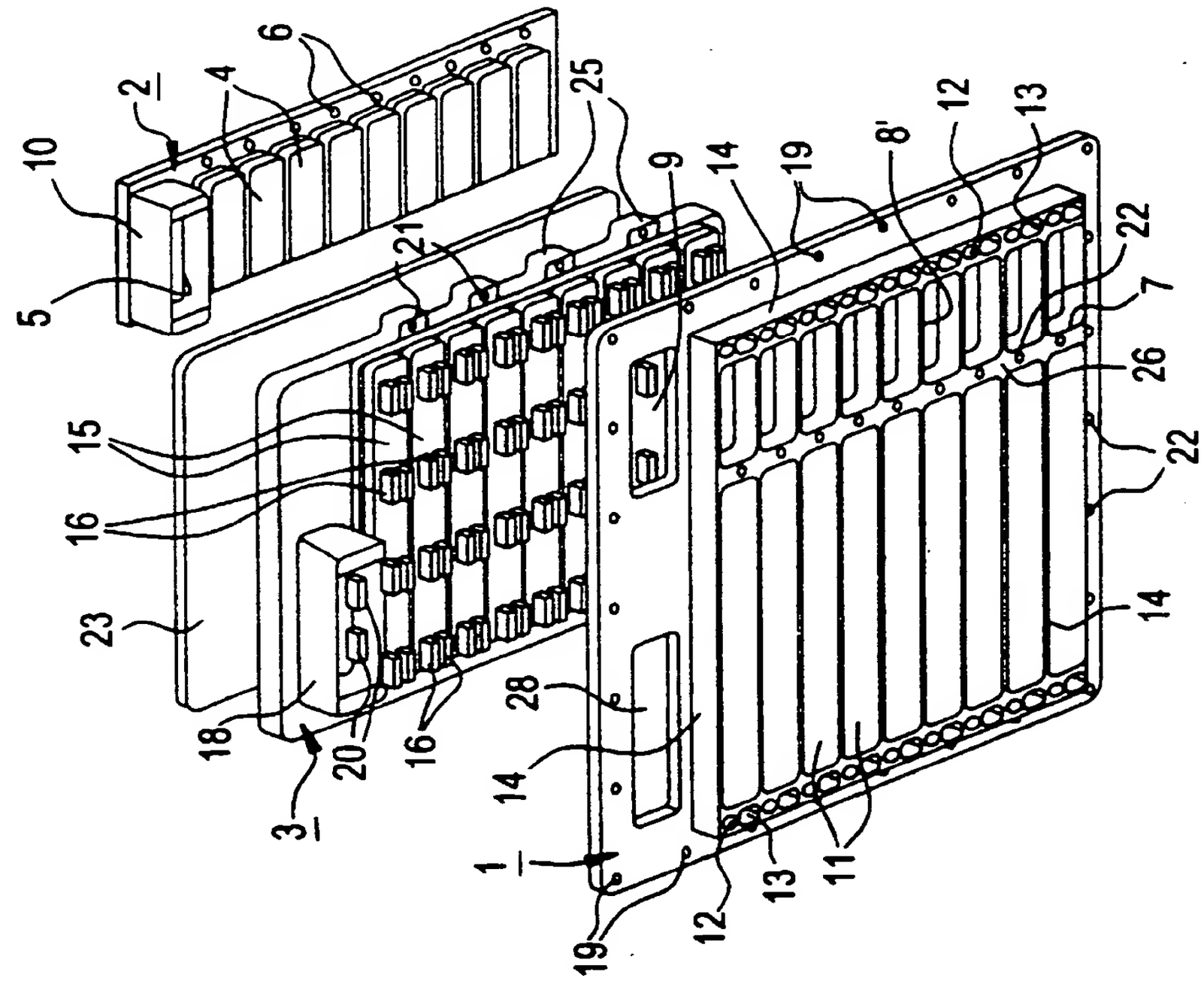


FIG. 1

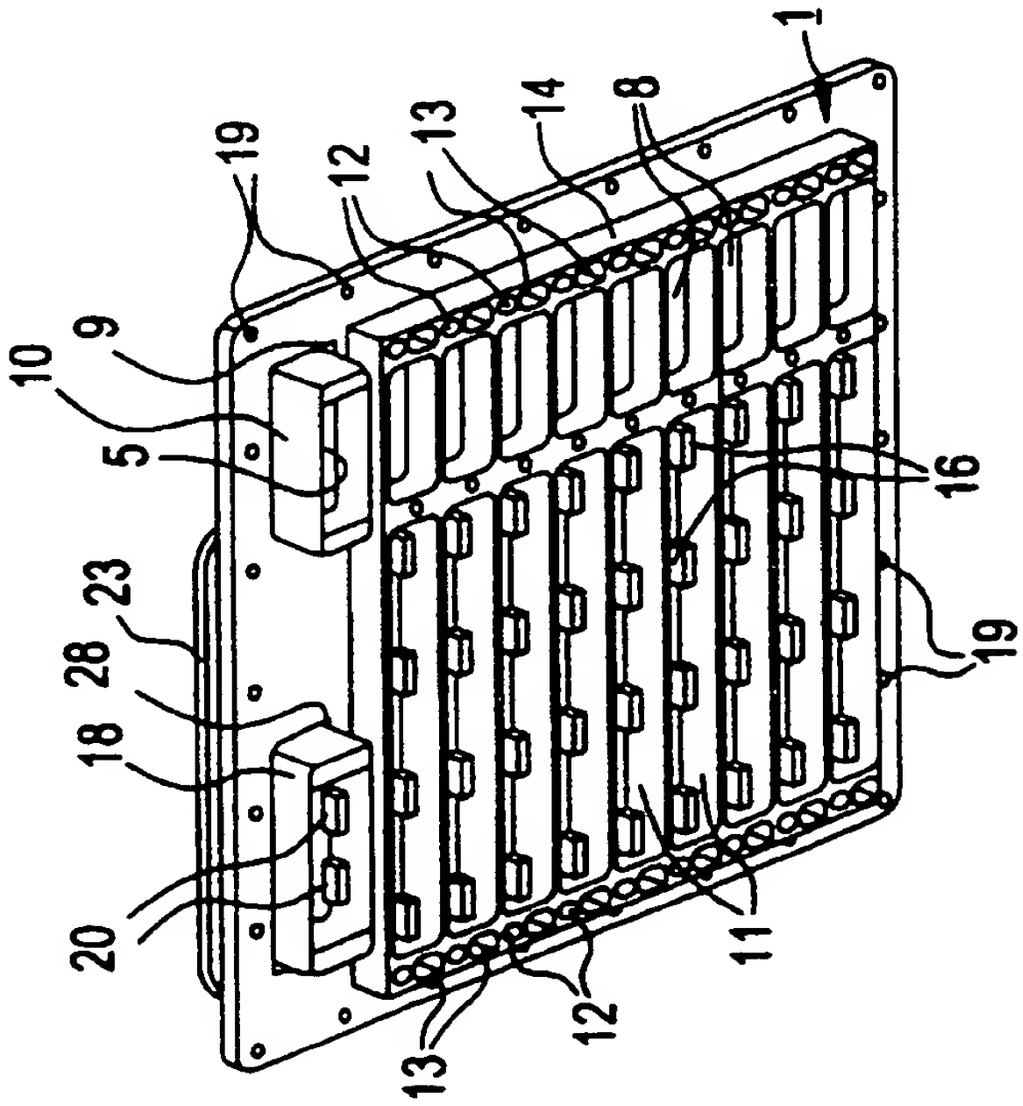


FIG. 4

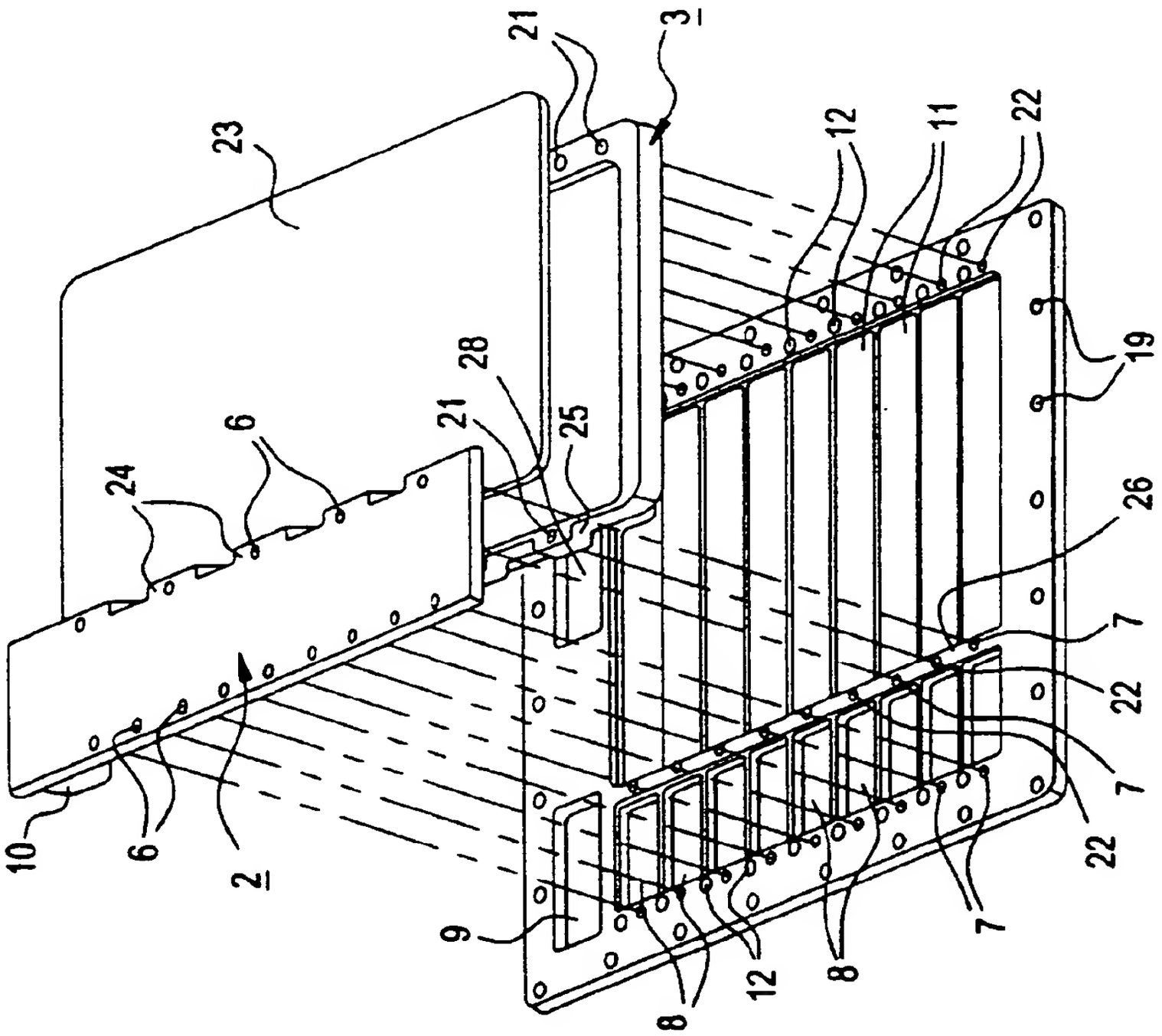


FIG. 3

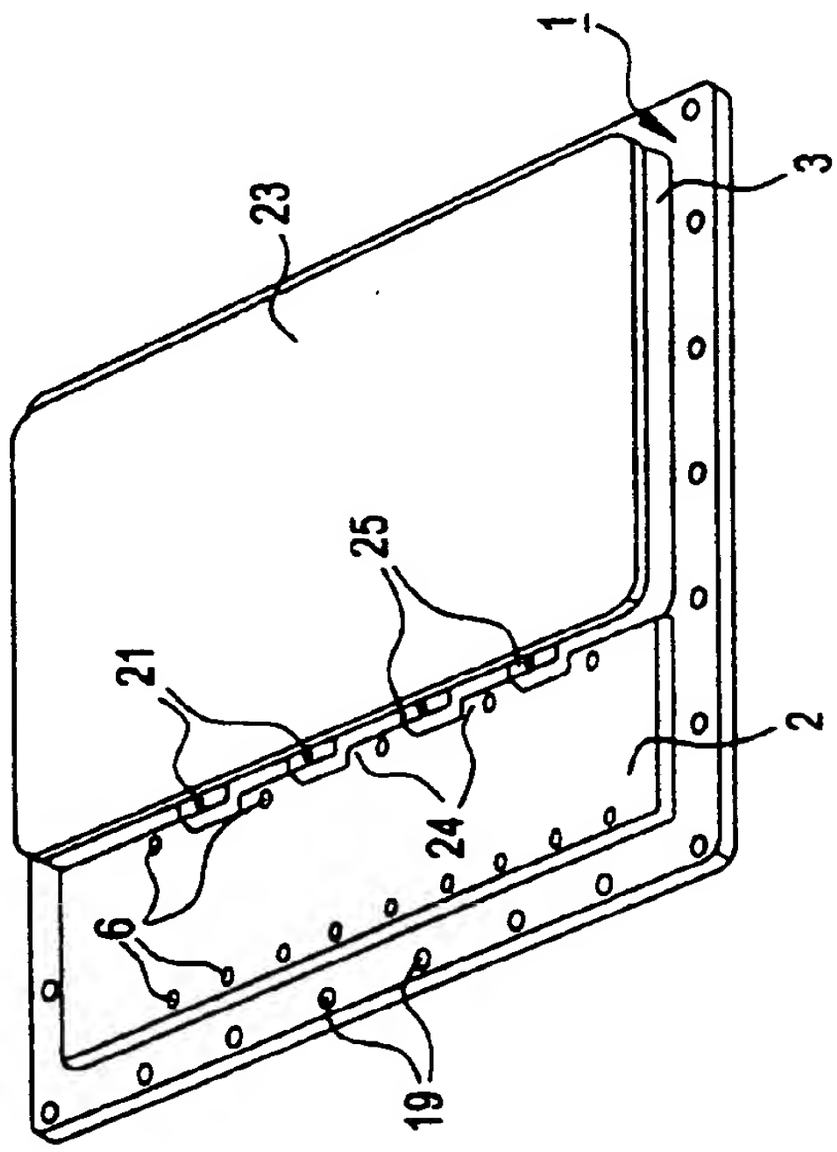


FIG. 6A

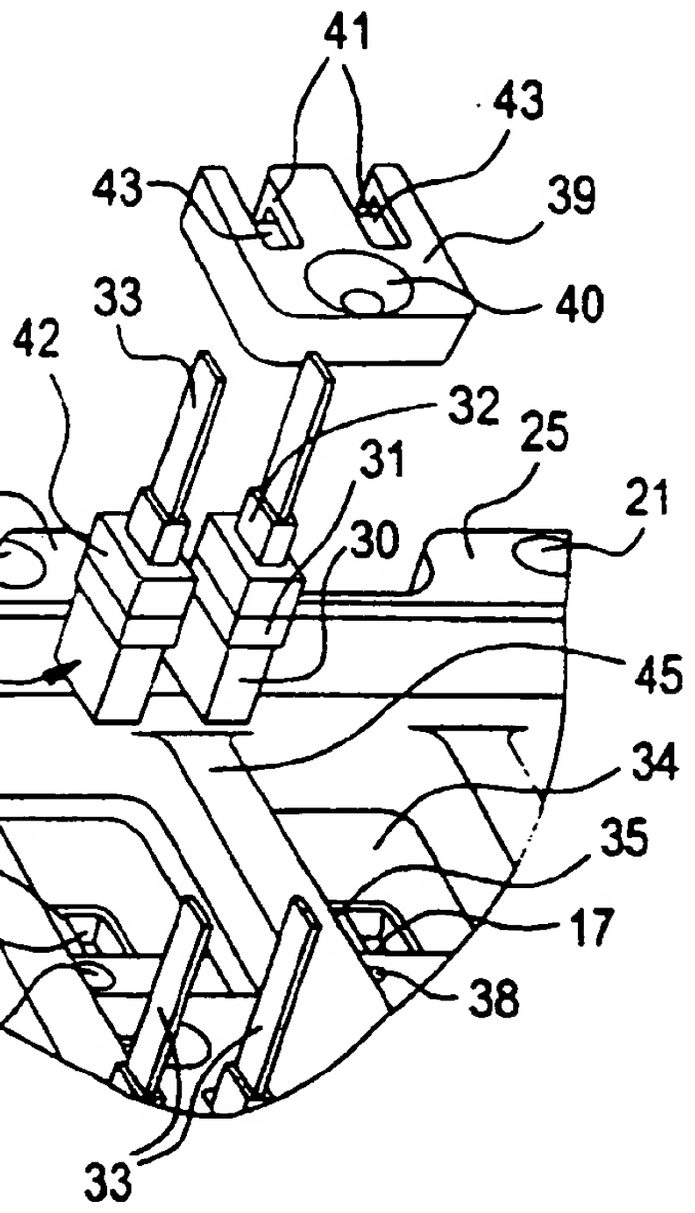


FIG. 7A

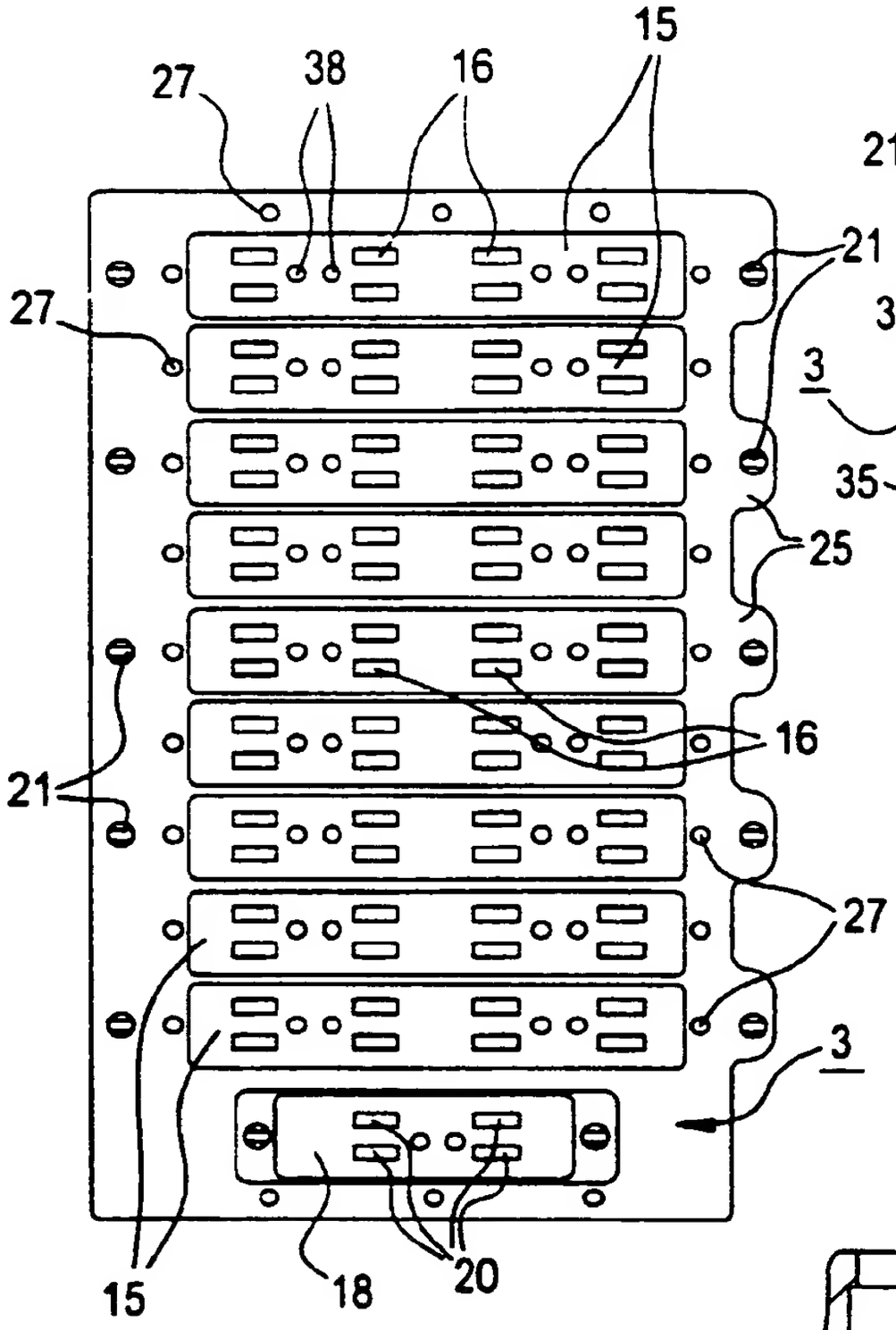


FIG. 5

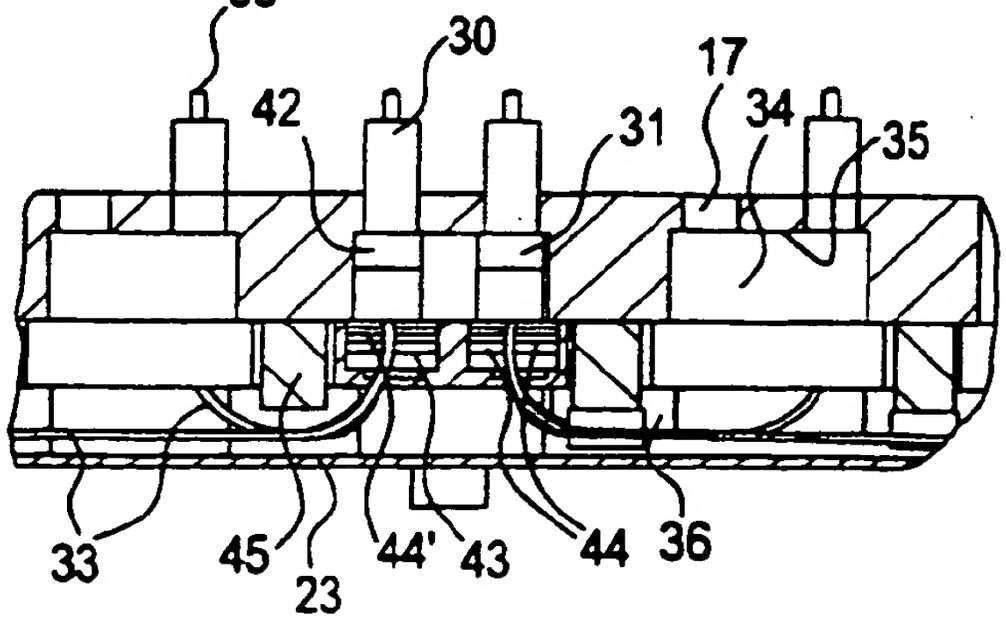


FIG. 6B

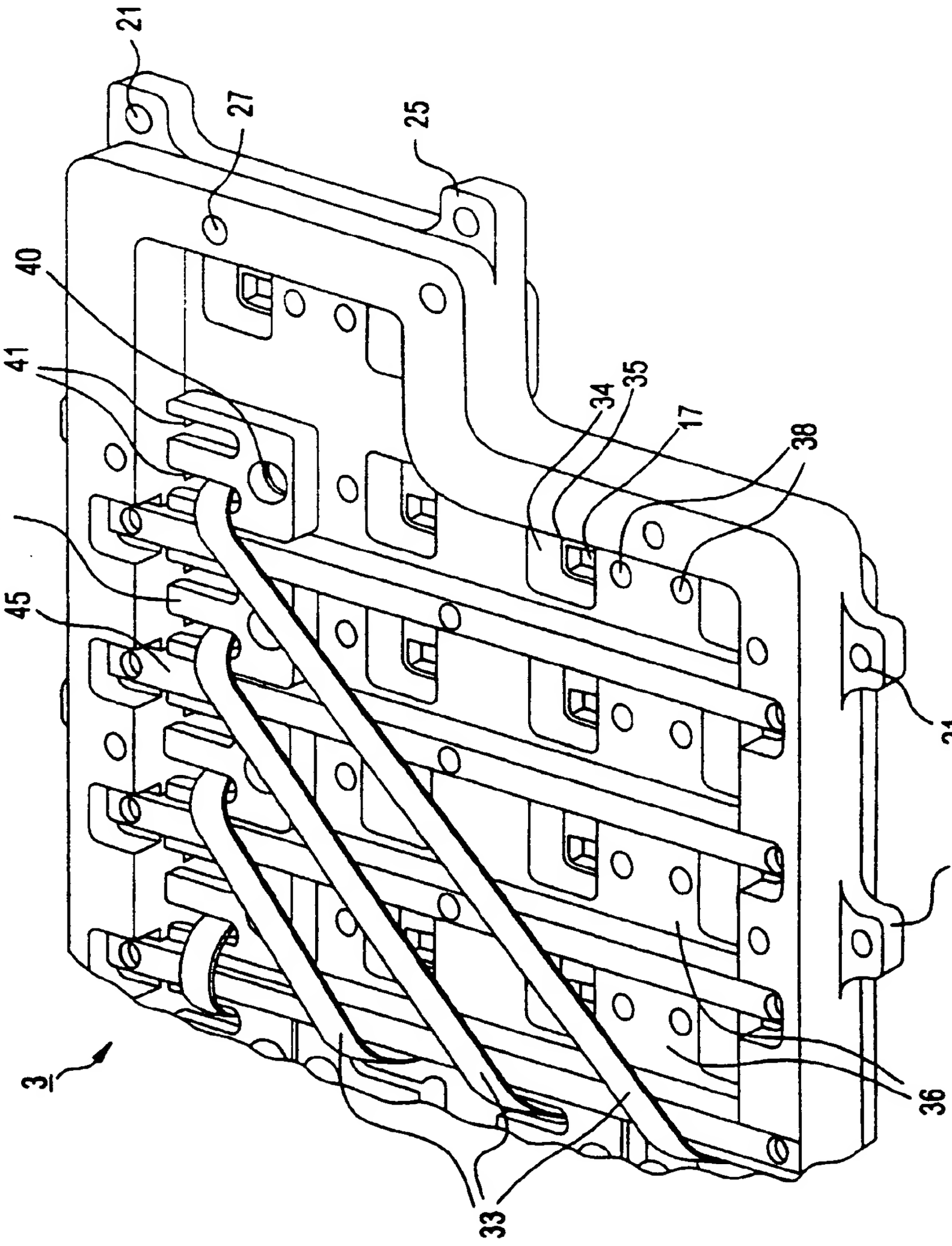


FIG. 7C

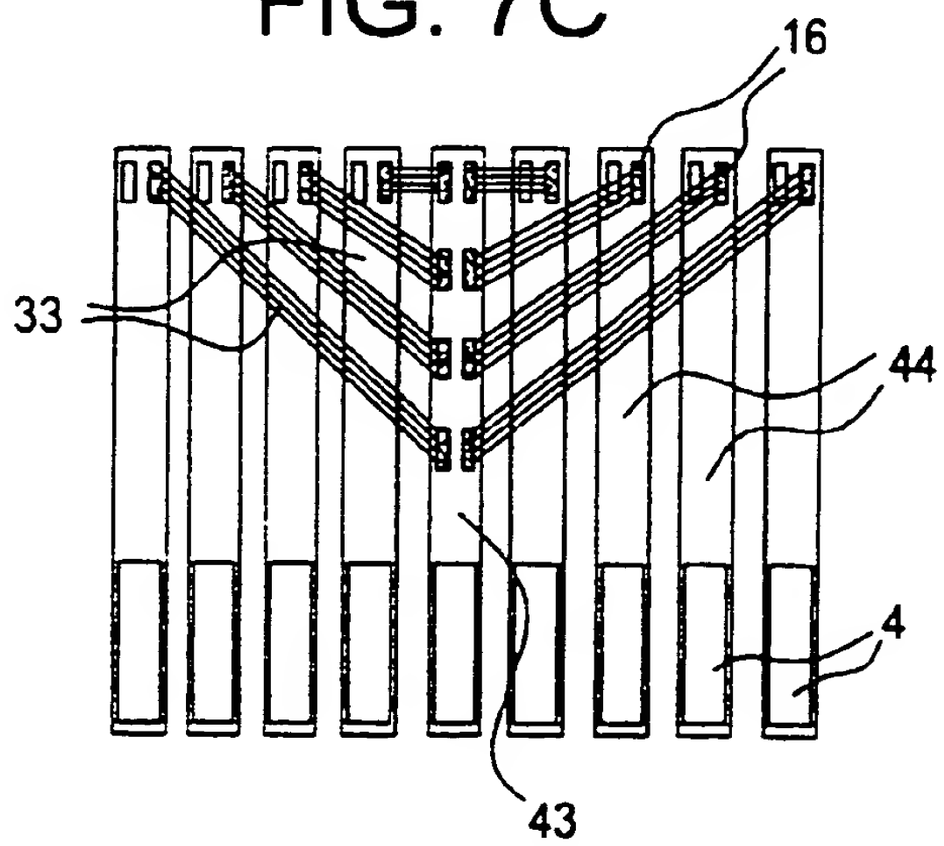


FIG. 7B

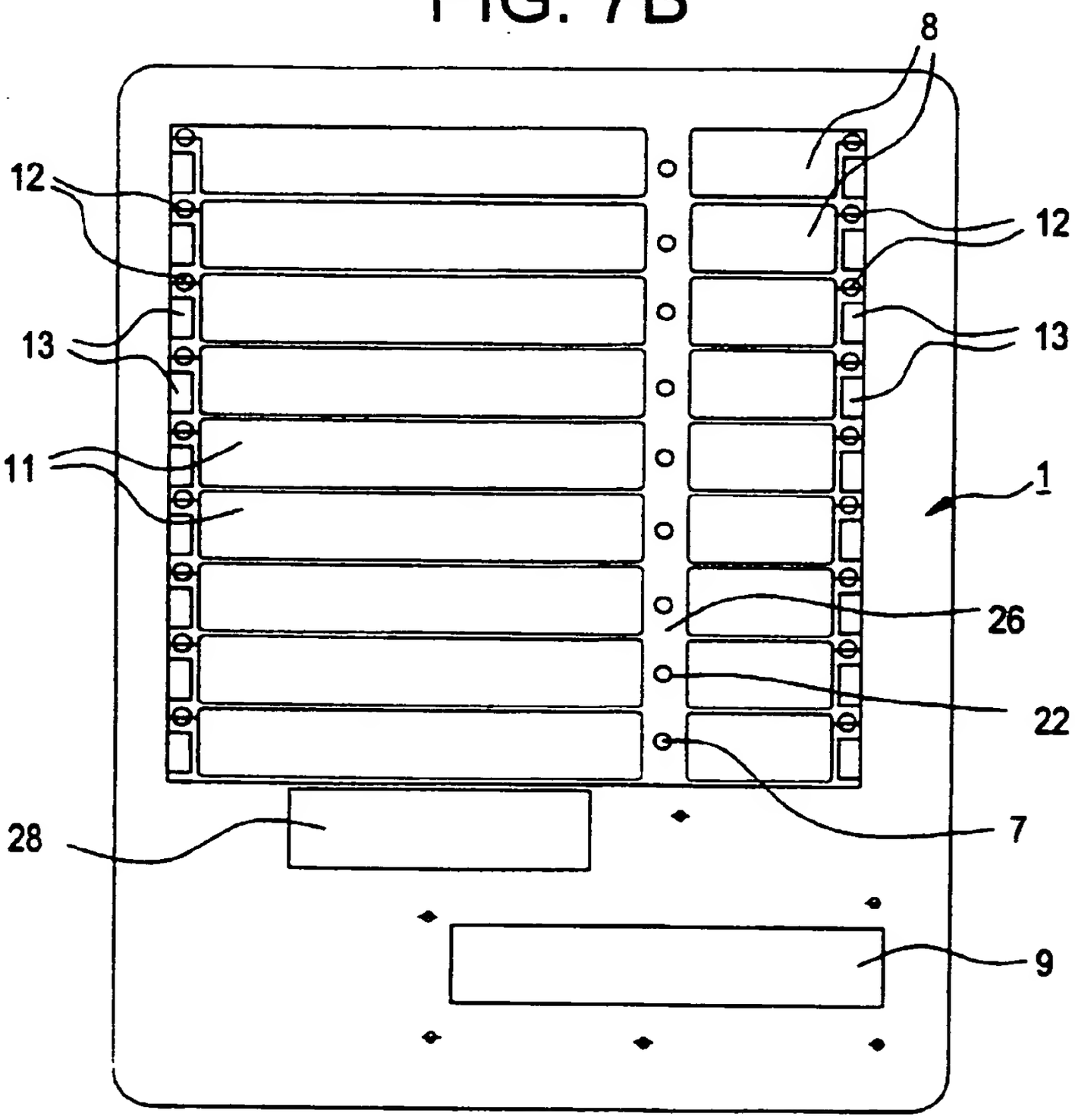


FIG. 10

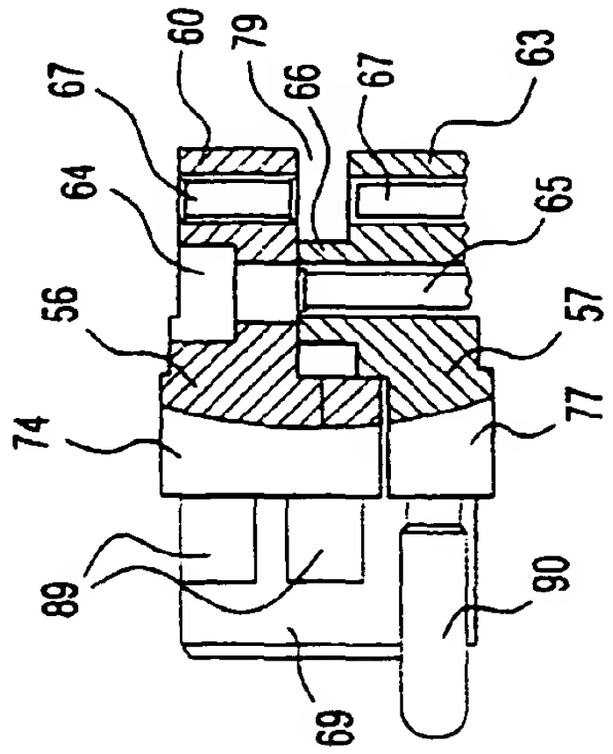


FIG. 8

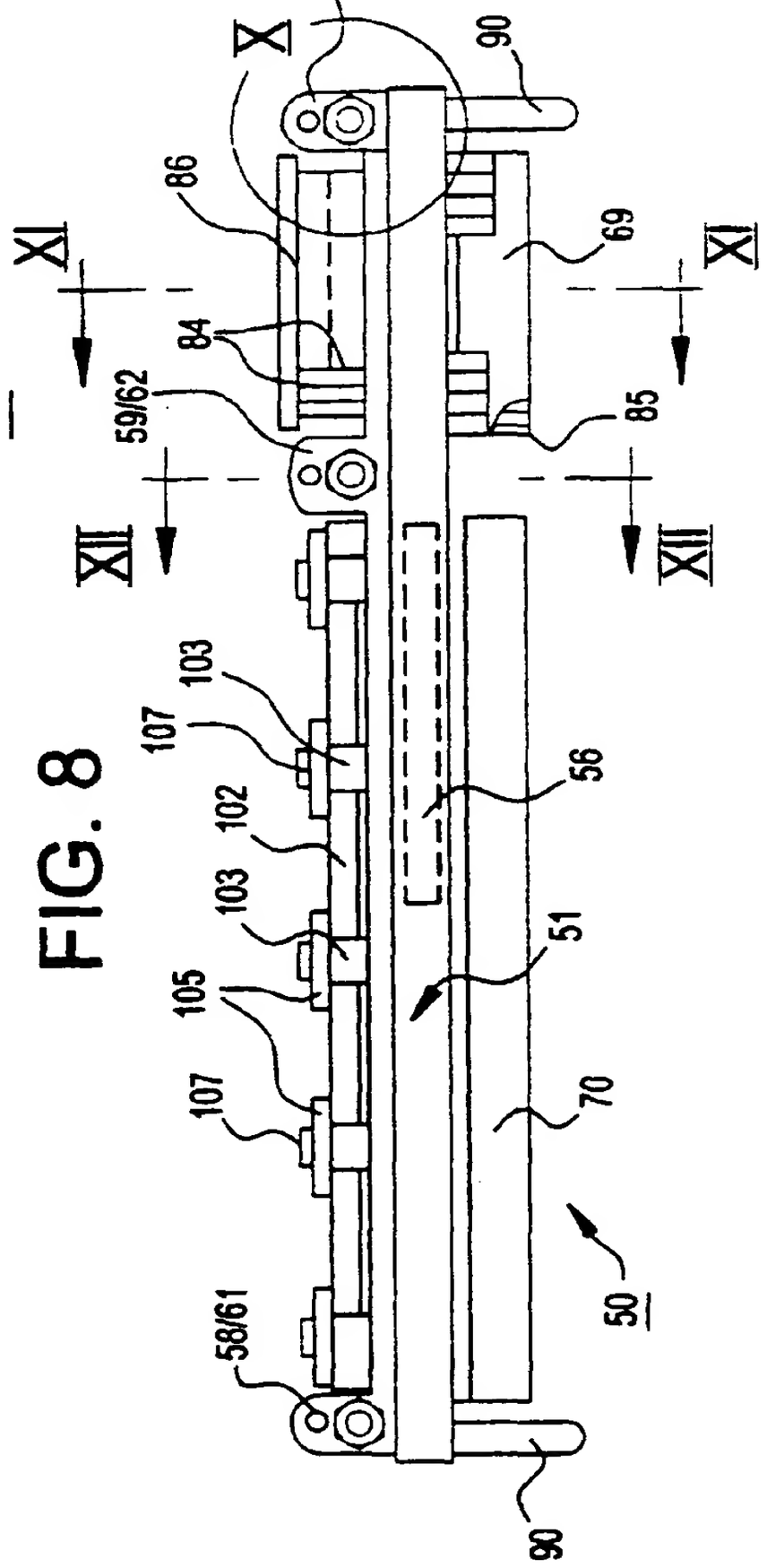


FIG. 9

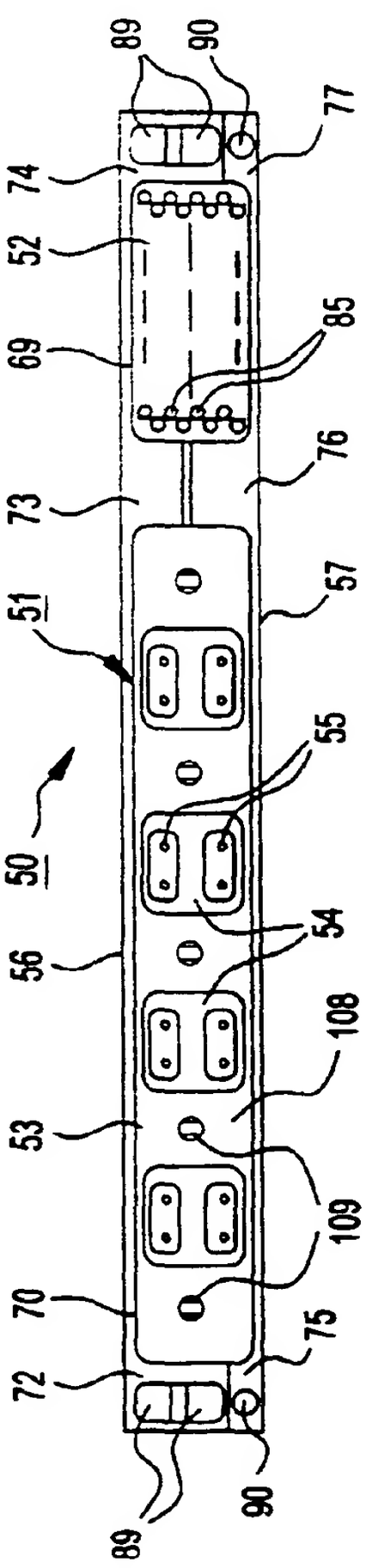


FIG. 11

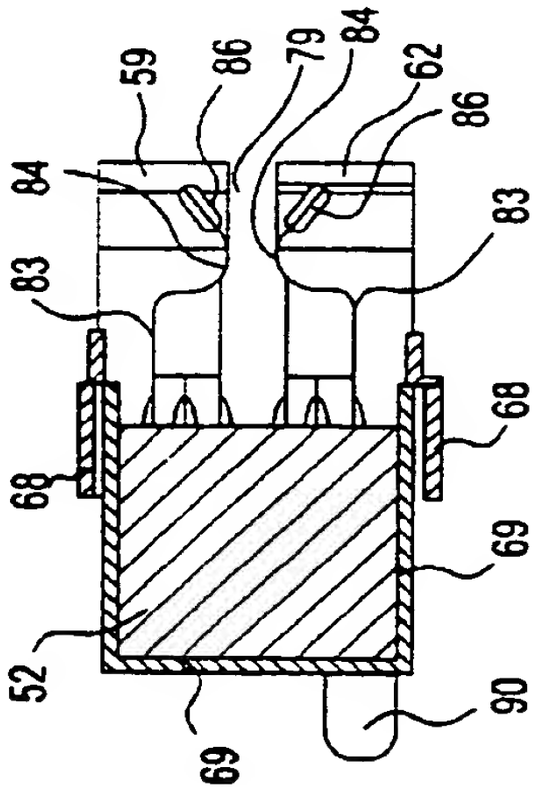


FIG. 13

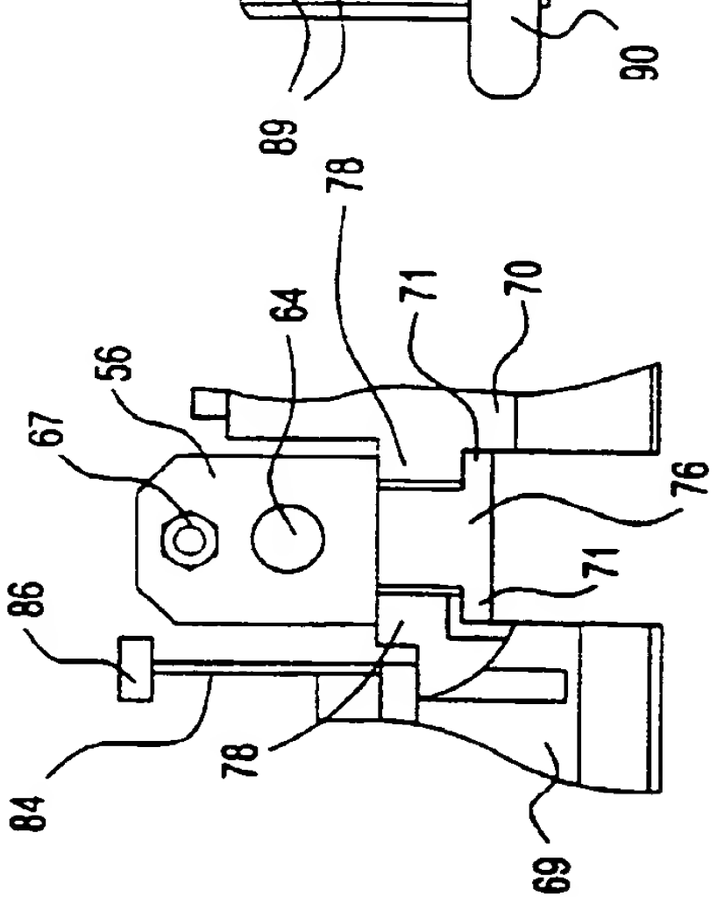


FIG. 14

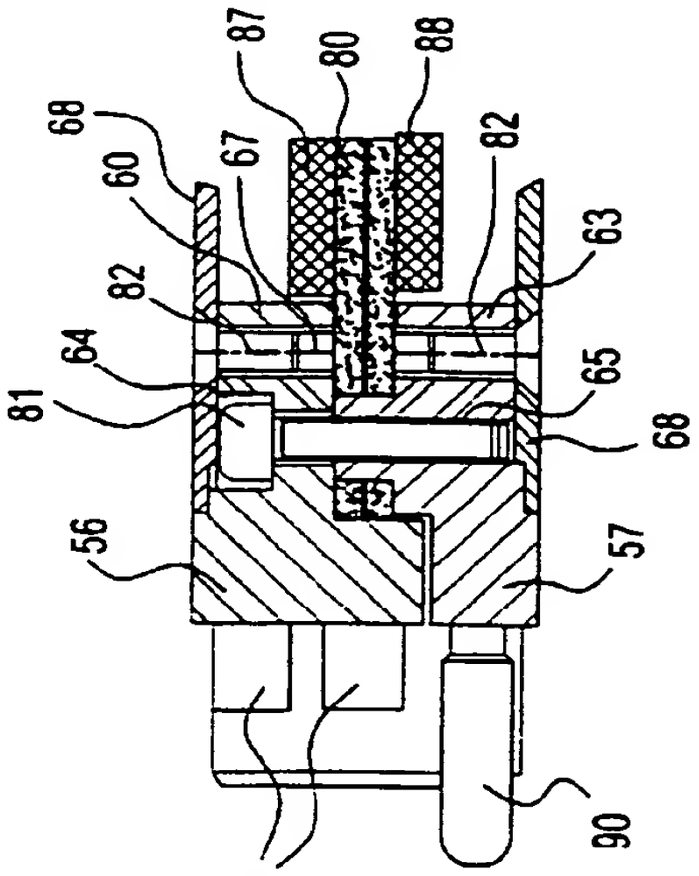


FIG. 12

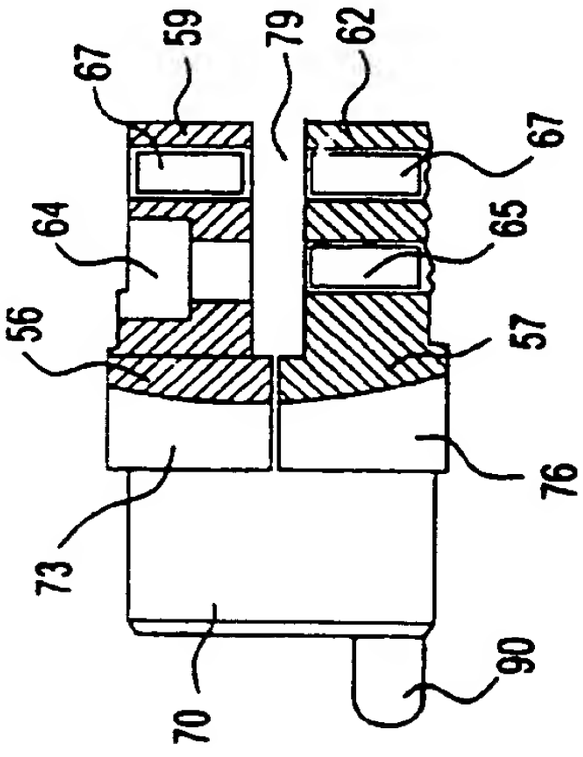


FIG. 16

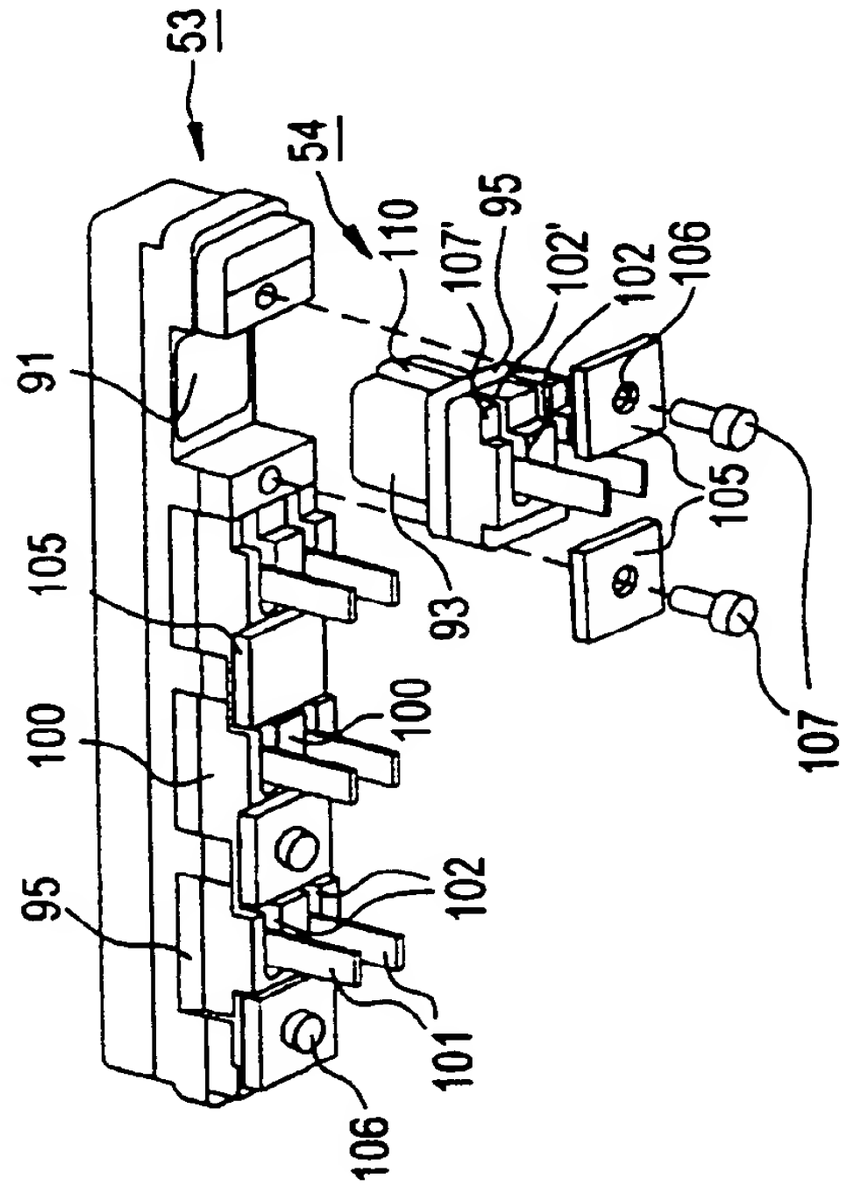


FIG. 17

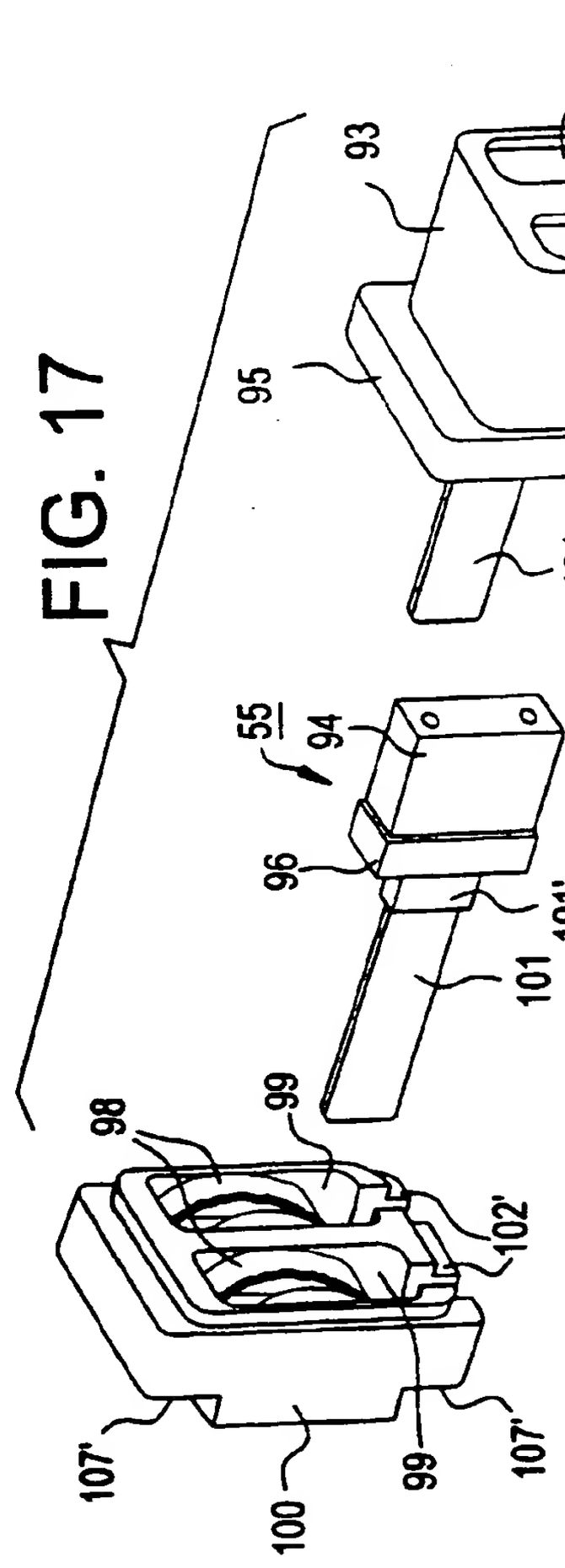


FIG. 15

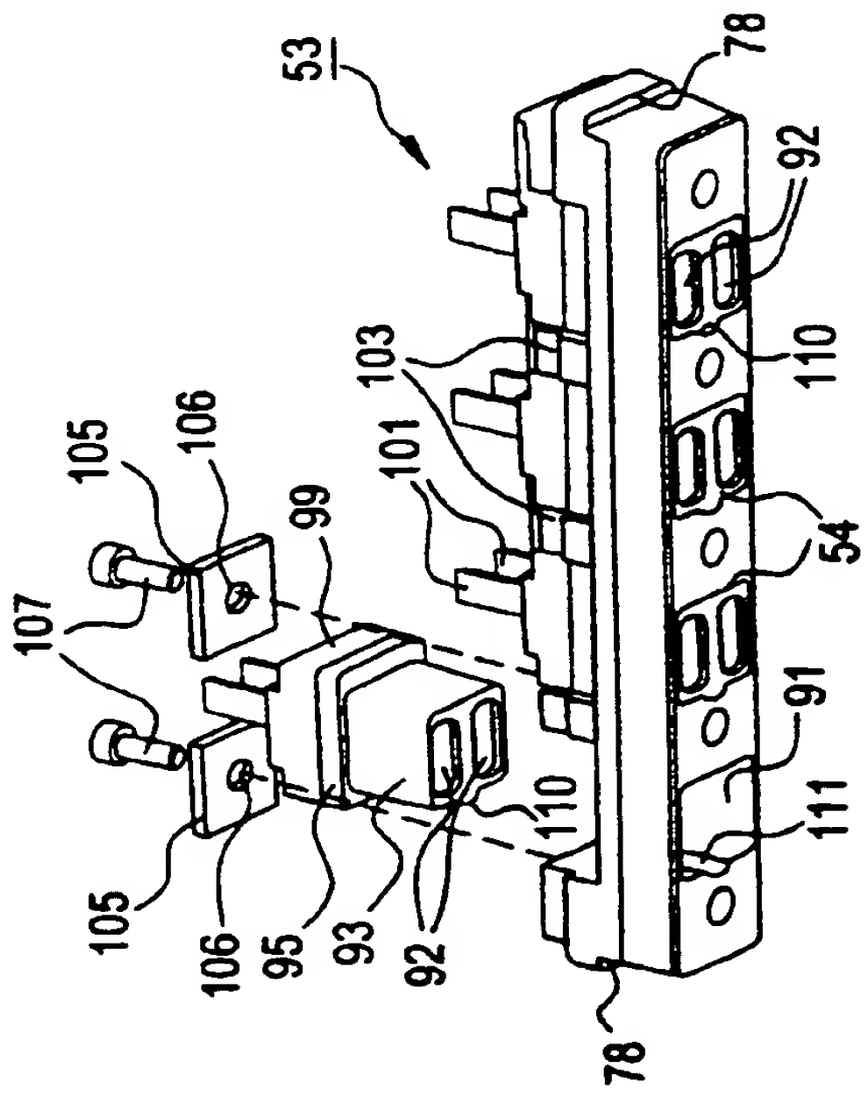
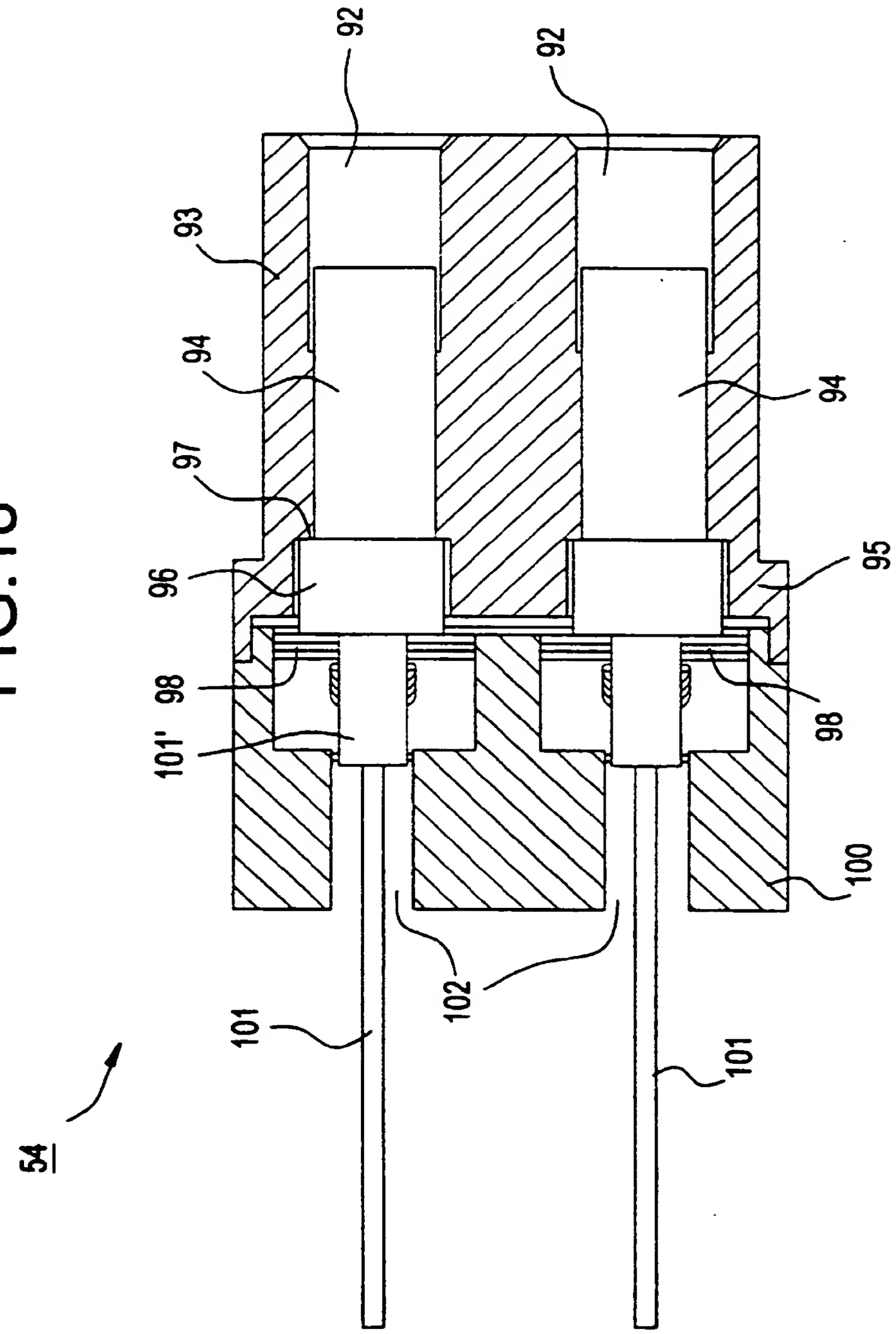


FIG.18



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 40 0066

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X,P A,P	EP 0 830 035 A (LUCENT TECHNOLOGIES INC) 18 March 1998 * claims; figures *	1 7	H04Q1/14 G02B6/43 G02B6/44
Y,D	US 5 204 929 A (MACHALL GREGORY A ET AL) 20 April 1993 * claims; figures *	1	
Y	US 5 448 675 A (LEONE FRANK S ET AL) 5 September 1995 * claims; figures *	1	
A,D	US 5 513 293 A (HOLLAND WILLIAM R ET AL) 30 April 1996 * claims; figures *	1	
A	WO 95 23991 A (MINNESOTA MINING & MFG) 8 September 1995 * claims; figures *	1	
A	EP 0 579 872 A (BELL TELEPHONE MFG ;ALCATEL NV (NL)) 26 January 1994 * claims; figures *	1	
A	EP 0 192 108 A (LOVRENICH RODGER T) 27 August 1986 * claims; figures *	1	
A	DE 33 21 303 A (KABELMETAL ELECTRO GMBH) 13 December 1984 * claims; figures *	1	
X,P A,P	EP 0 828 356 A (LUCENT TECHNOLOGIES INC) 11 March 1998 * claims; figures *	1 2,5,6, 11,13,14	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
H04Q
G02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 April 1999	Pfahler, R

EPO FORM 1503 03.82 (P04C01)

CATEGORY OF CITED DOCUMENTS

X particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 40 0066

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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15-04-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0830035 A	18-03-1998	US 5724468 A	03-03-1998
		CA 2211771 A	09-03-1998
		JP 10108224 A	24-04-1998
US 5204929 A	20-04-1993	NONE	
US 5448675 A	05-09-1995	CA 2147909 A	10-12-1995
		EP 0687115 A	13-12-1995
		JP 7336732 A	22-12-1995
US 5513293 A	30-04-1996	NONE	
WO 9523991 A	08-09-1995	US 5402515 A	28-03-1995
		AU 689233 B	26-03-1998
		AU 1910795 A	18-09-1995
		CA 2184595 A	08-09-1995
		EP 0748462 A	18-12-1996
		JP 9509753 T	30-09-1997
EP 0579872 A	26-01-1994	DE 69227028 D	22-10-1998
		DE 69227028 T	25-02-1999
		ES 2124240 T	01-02-1999
EP 0192108 A	27-08-1986	US 4621200 A	04-11-1986
		AT 77497 T	15-07-1992
		AU 591092 B	30-11-1989
		AU 5322086 A	14-08-1986
		BR 8600569 A	21-10-1986
		CA 1311043 A	01-12-1992
		DE 3685666 A	23-07-1992
		JP 61187447 A	21-08-1986
		US 4705960 A	10-11-1987
DE 3321303 A	13-12-1984	NONE	
EP 0828356 A	11-03-1998	US 5793909 A	11-08-1998
		CA 2212759 A	09-03-1998
		JP 10107739 A	24-04-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

FIG. 2

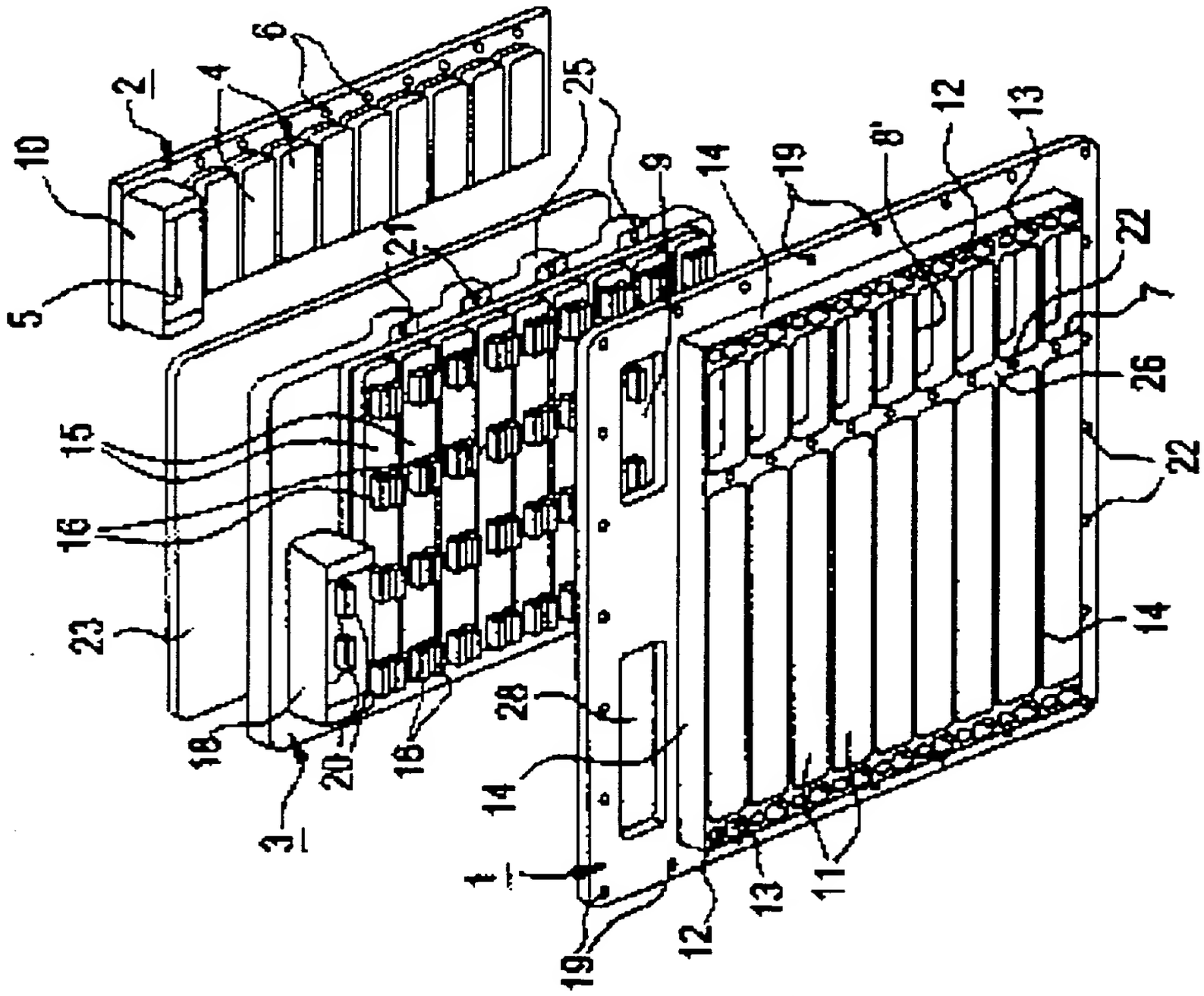


FIG. 1

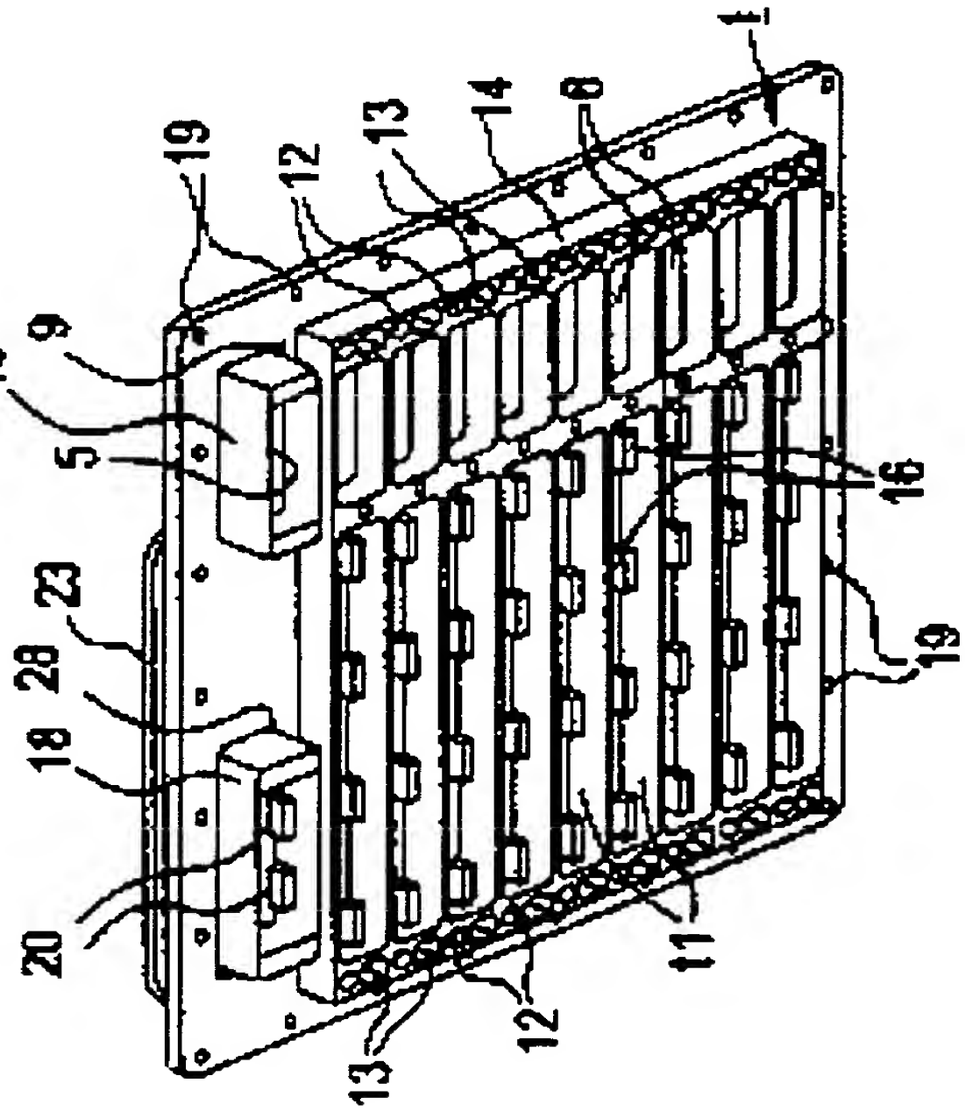
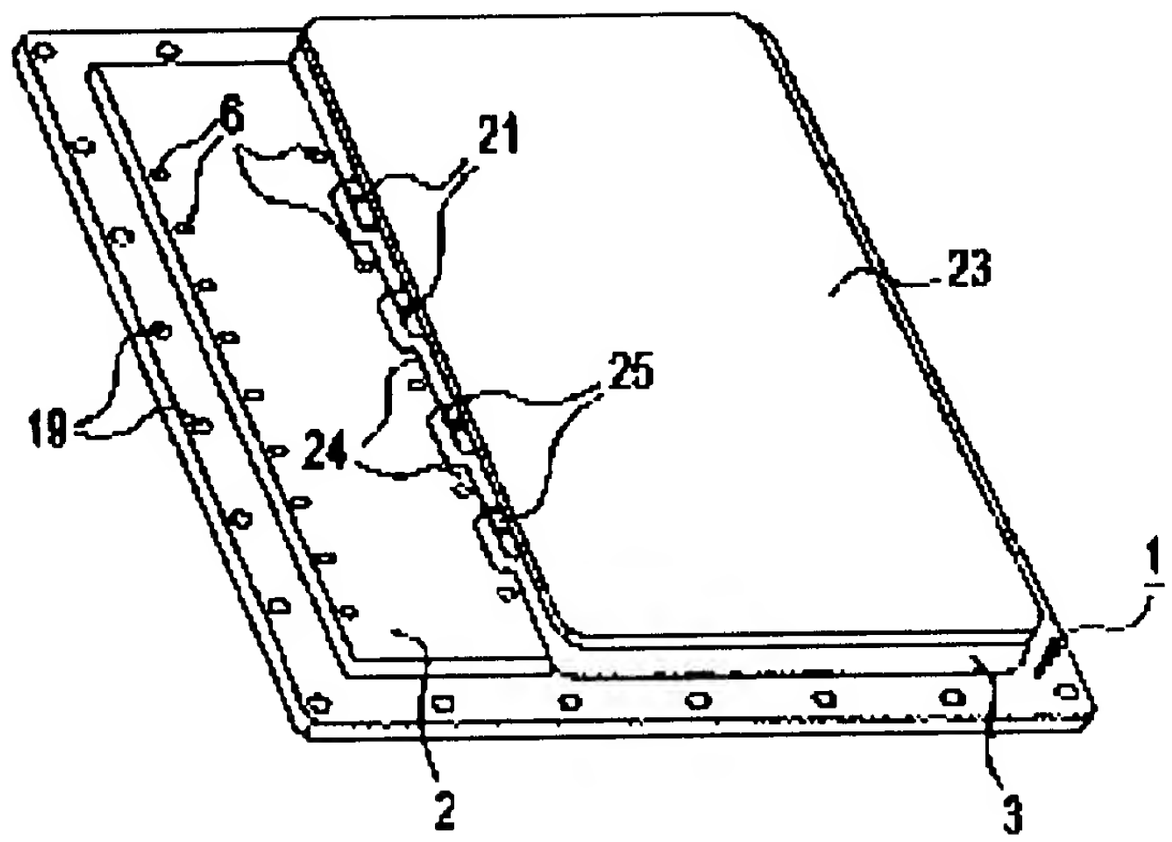


FIG. 3



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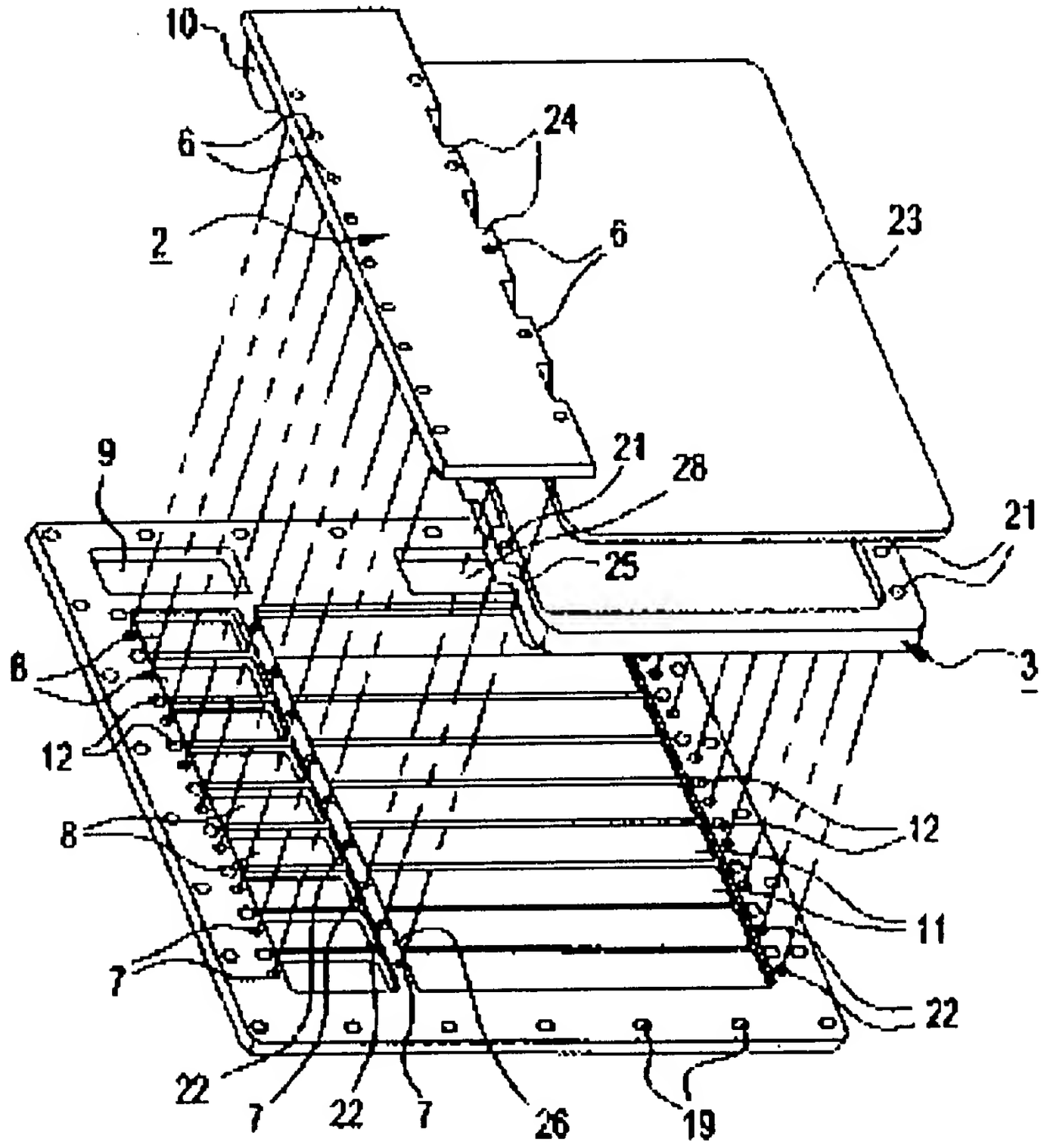


FIG. 6A

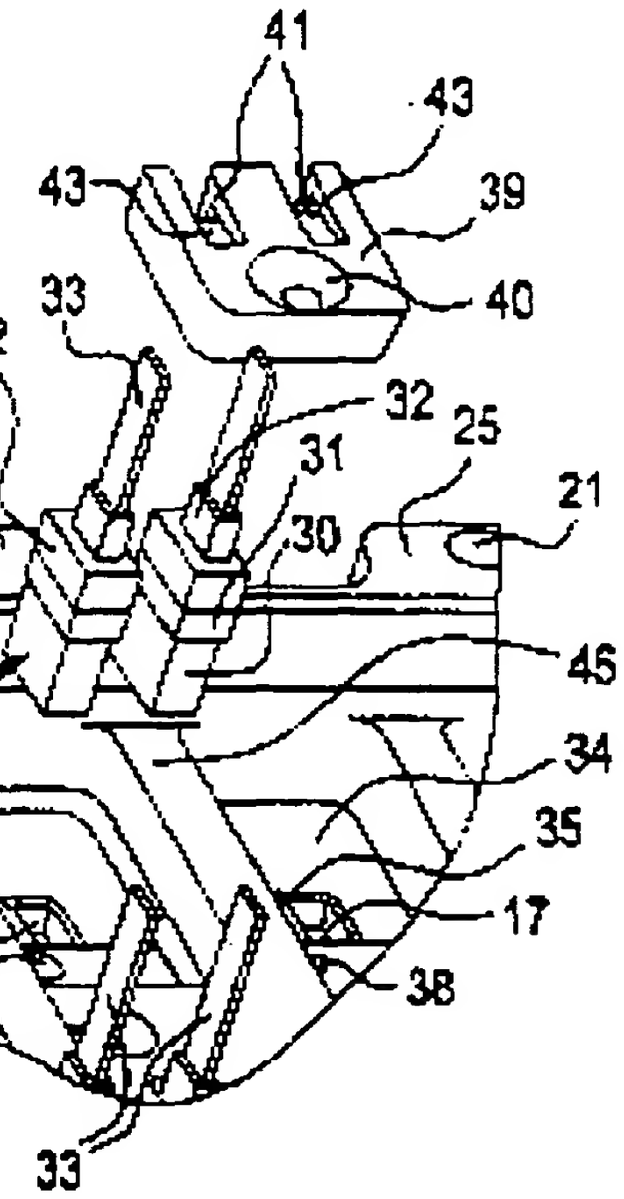


FIG. 7A

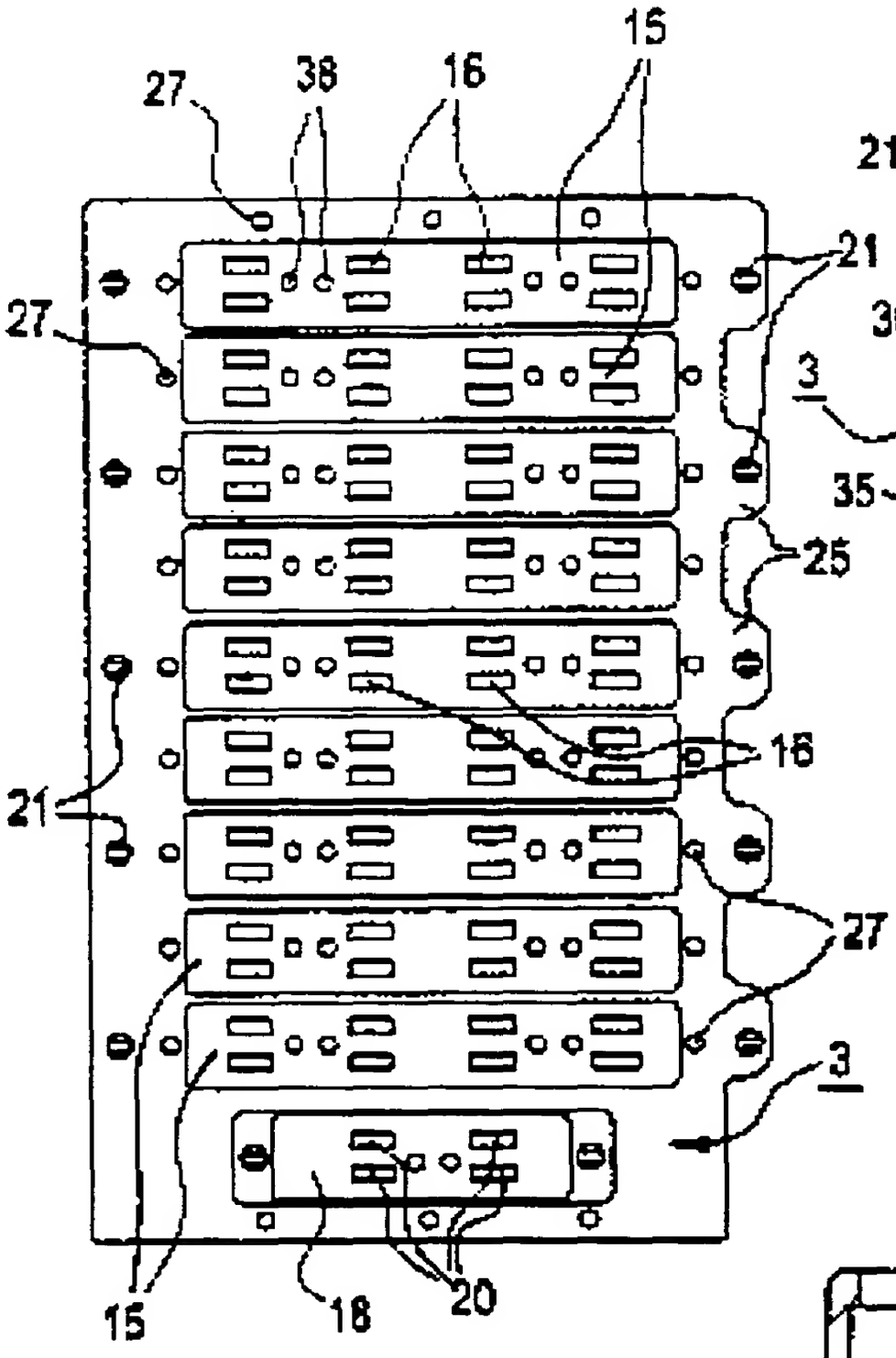


FIG. 5

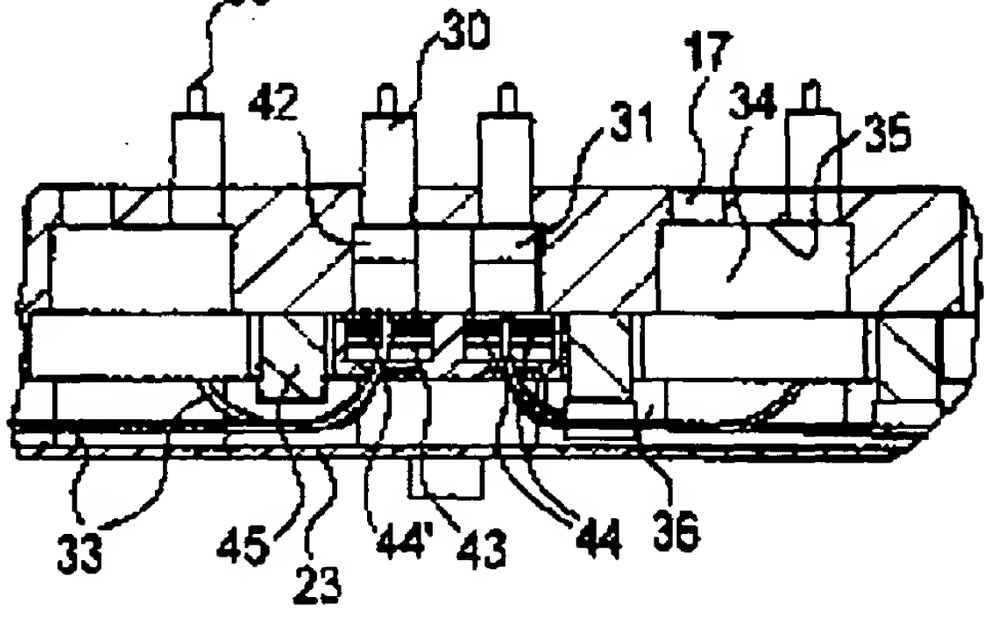


FIG. 6B

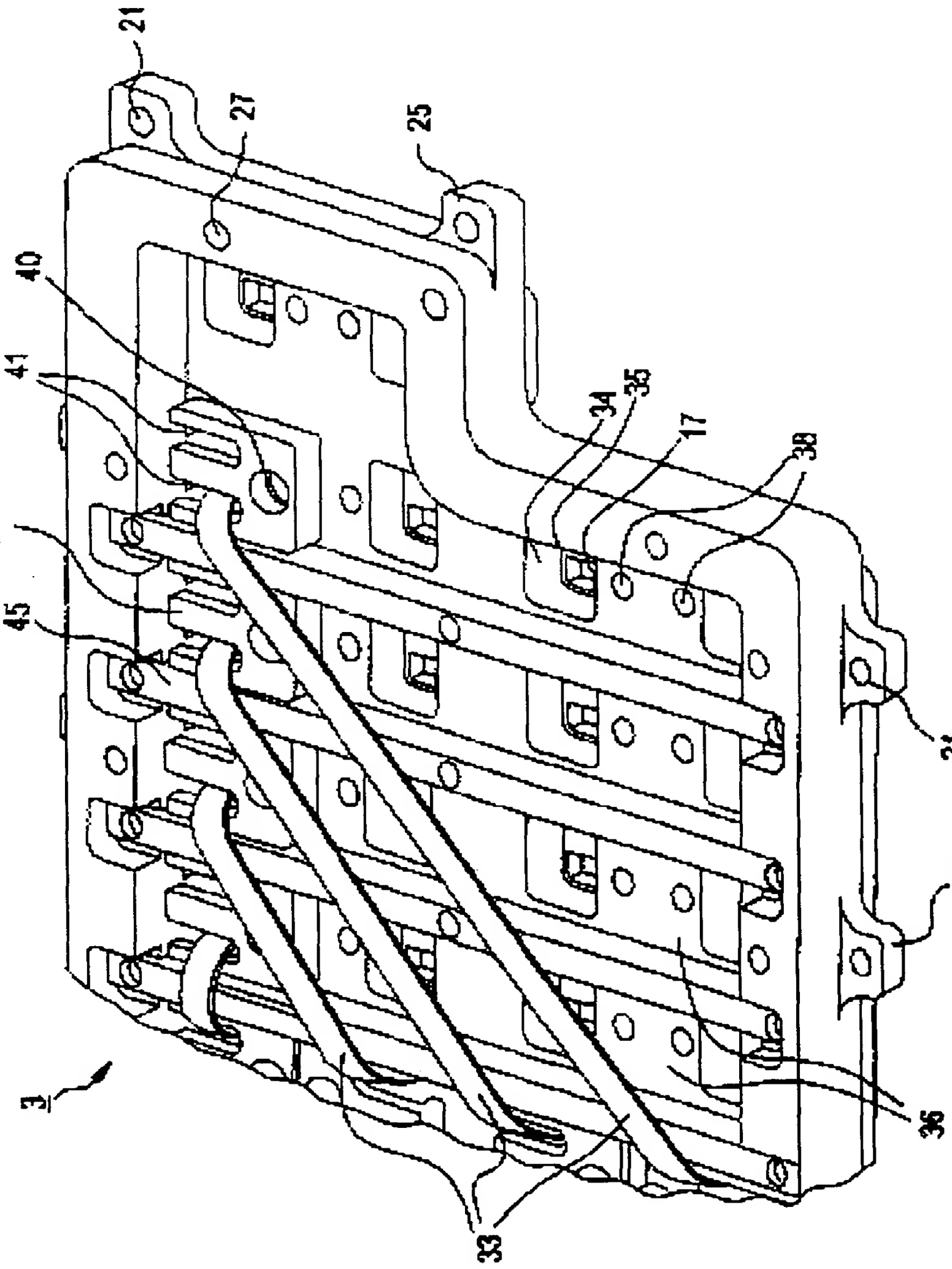


FIG. 7C

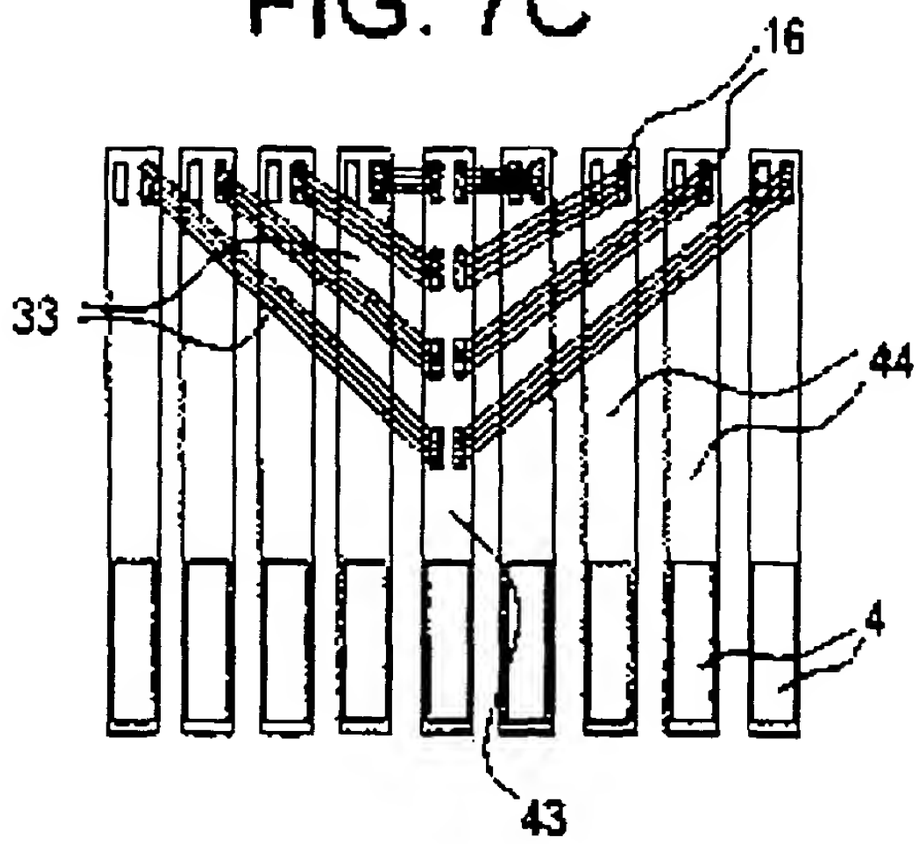


FIG. 7B

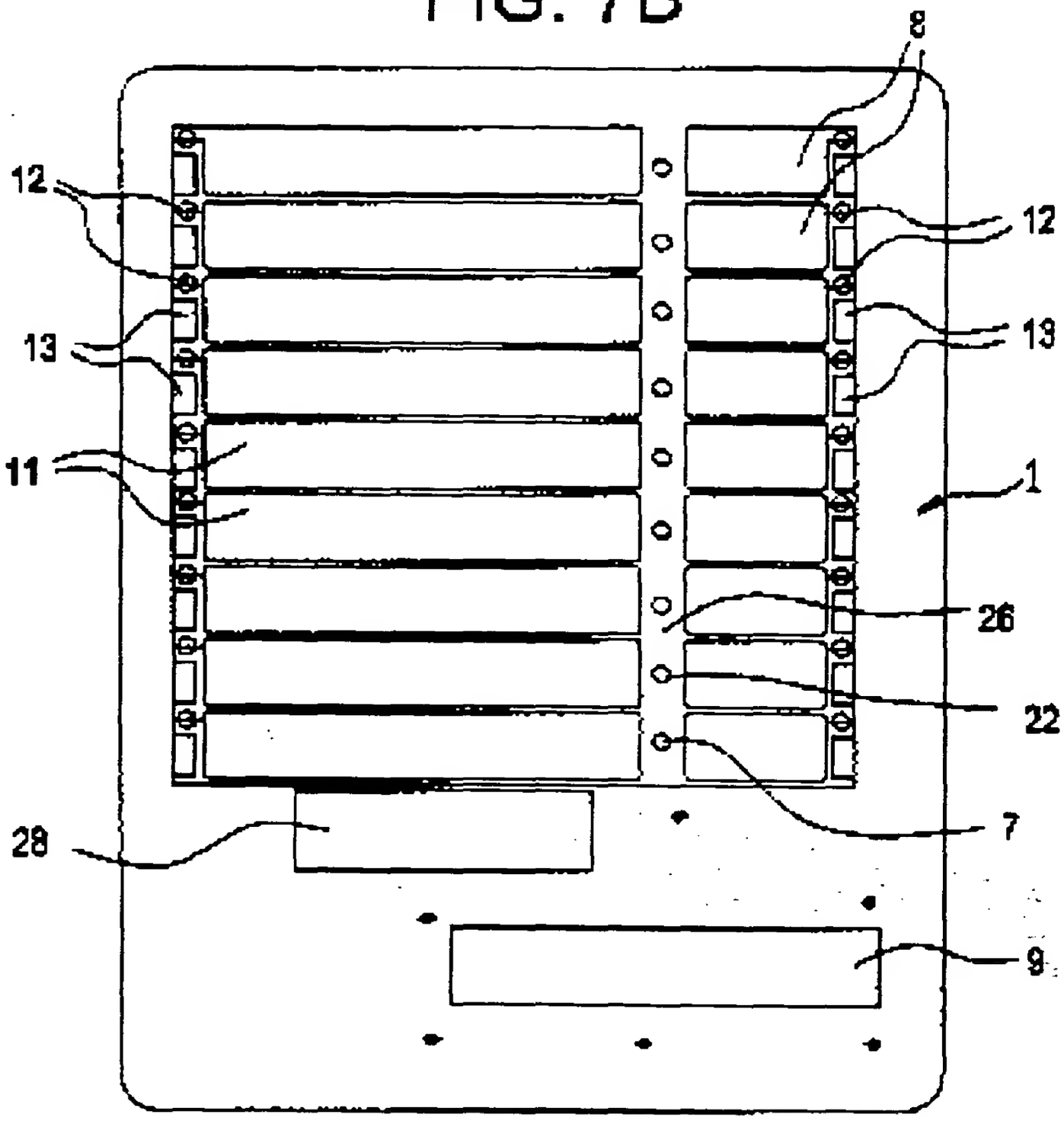
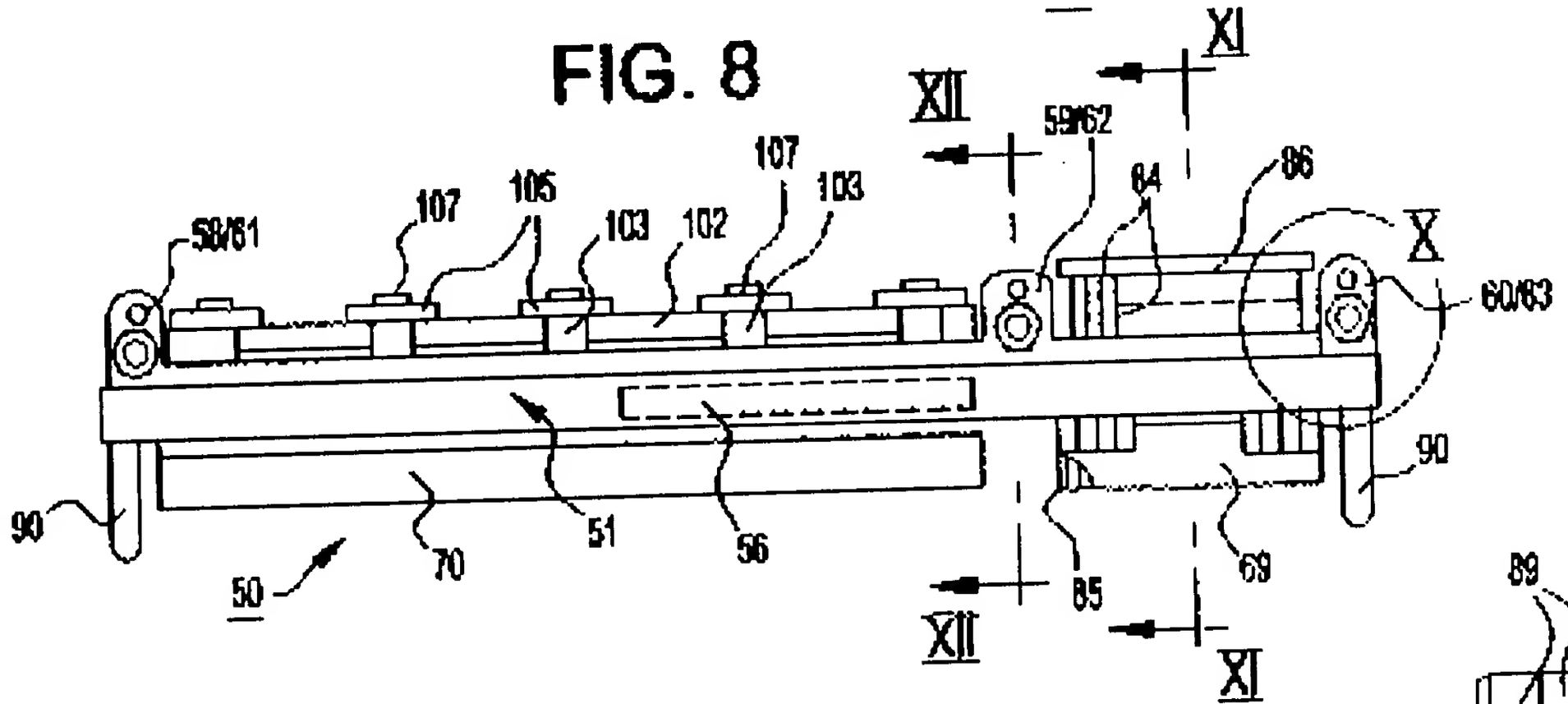


FIG. 8



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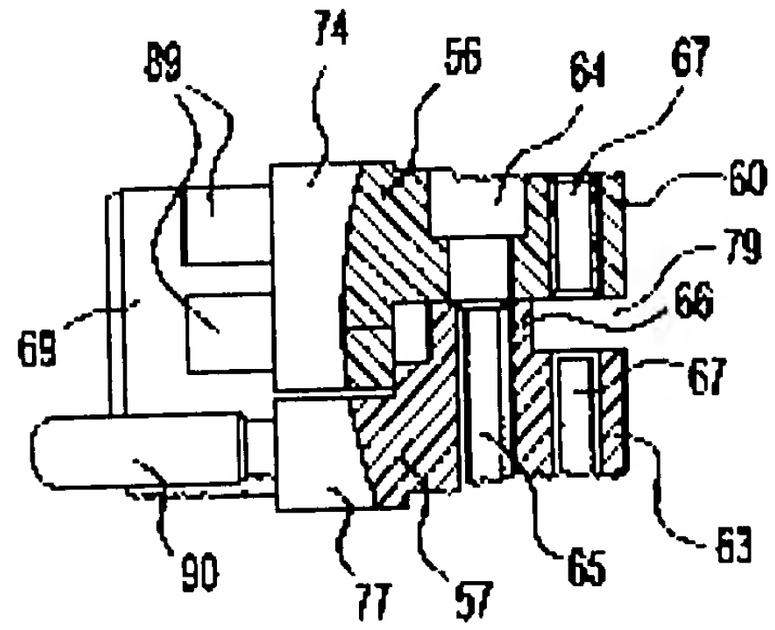

FIG. 9

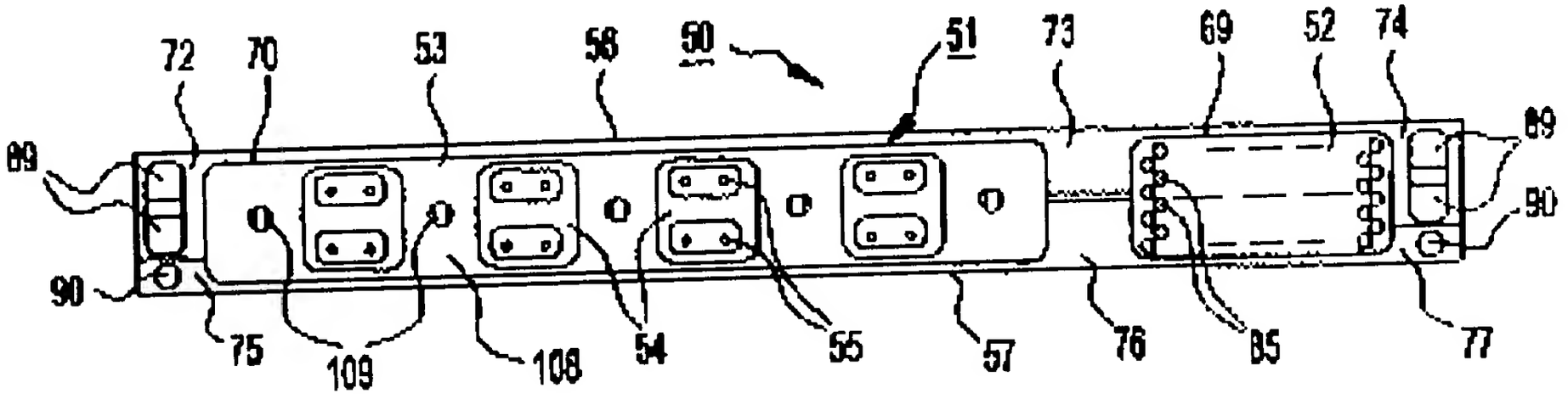

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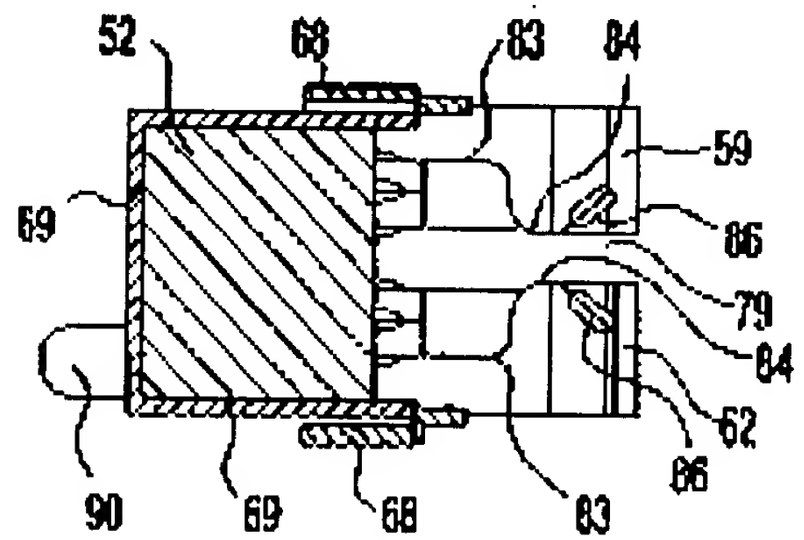
FIG. 11



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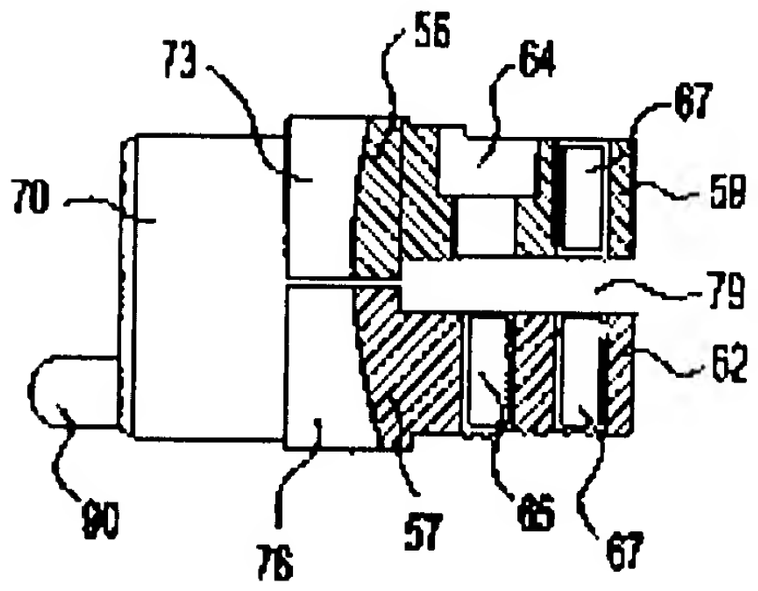

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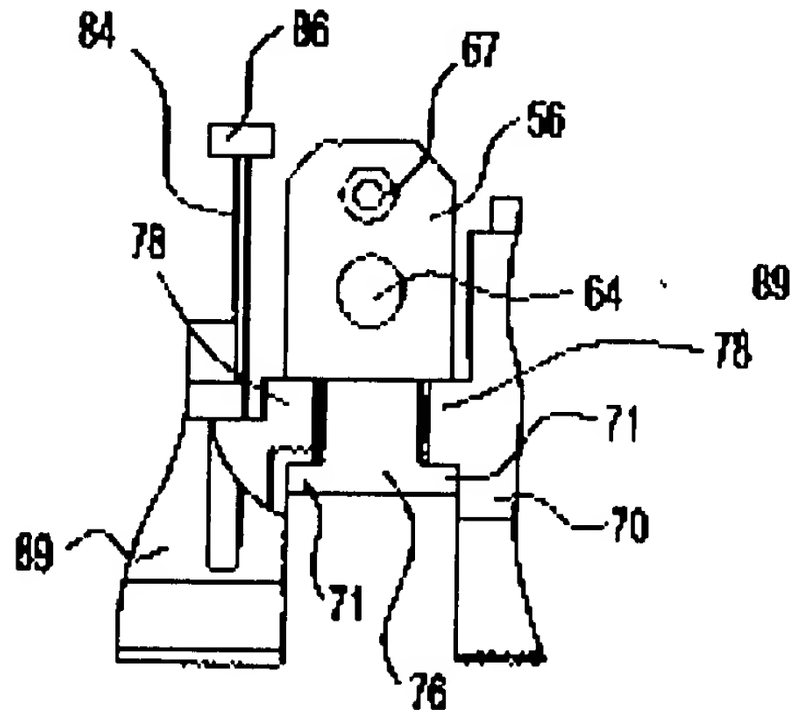
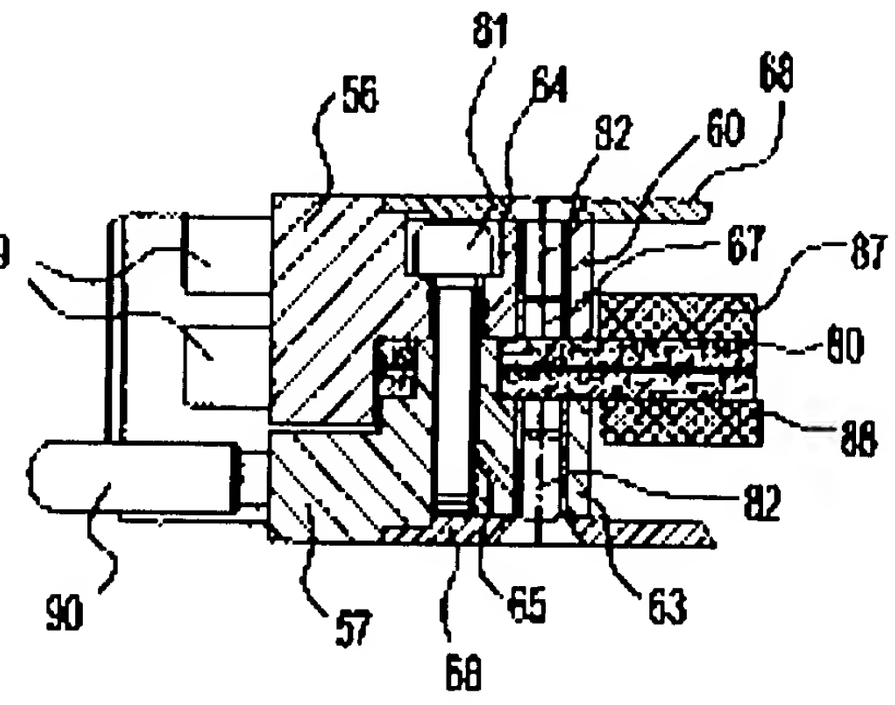


FIG. 14



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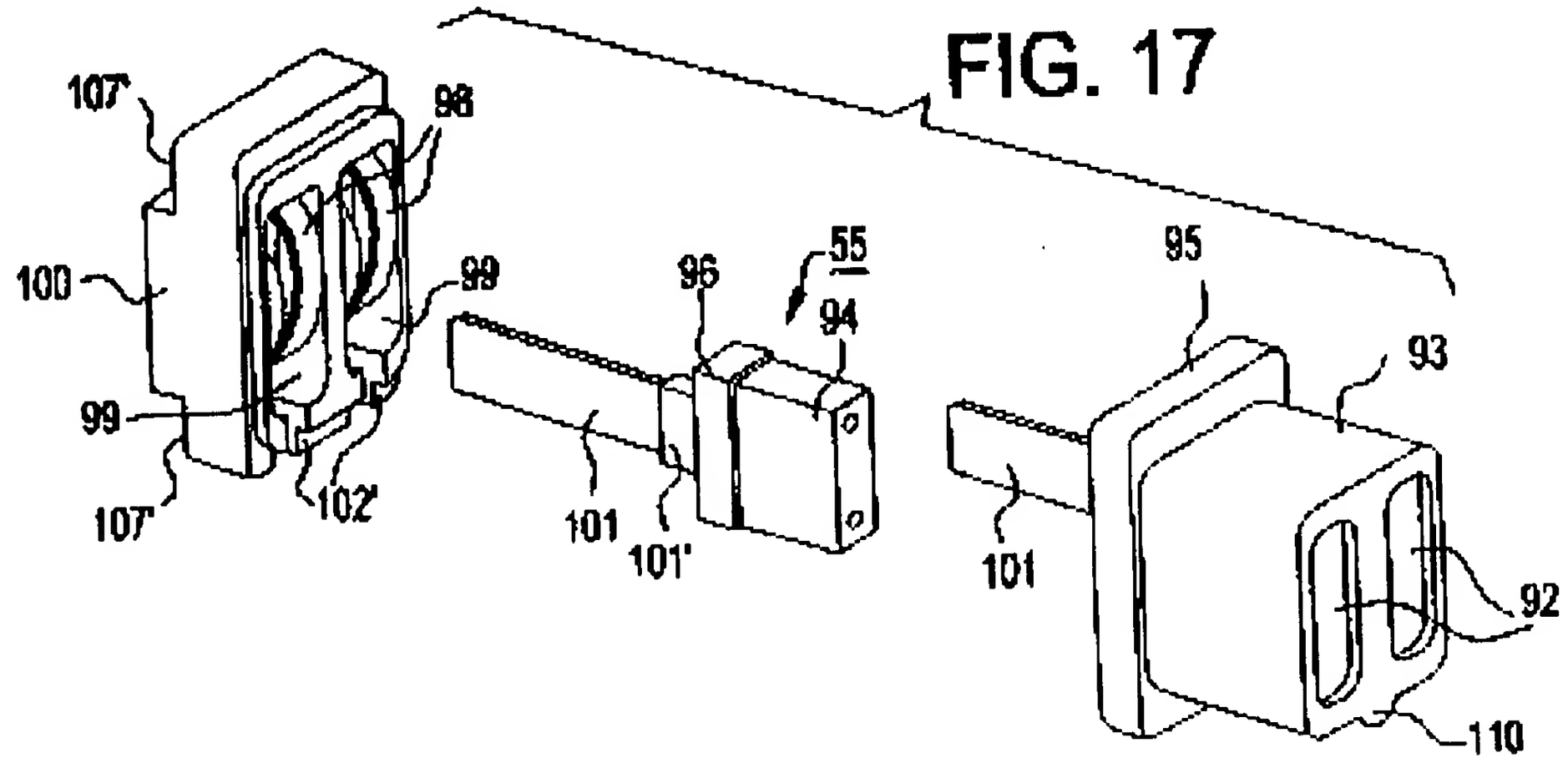
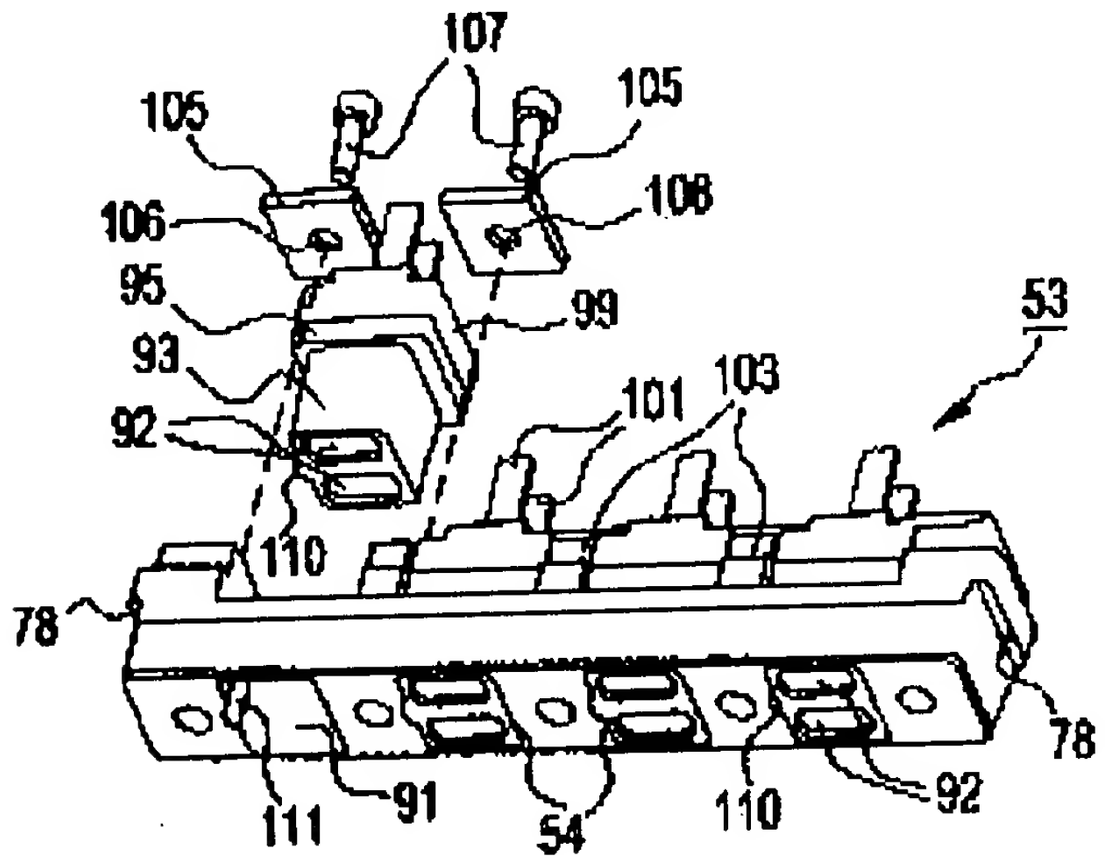


FIG. 17

FIG. 15

FIG. 16



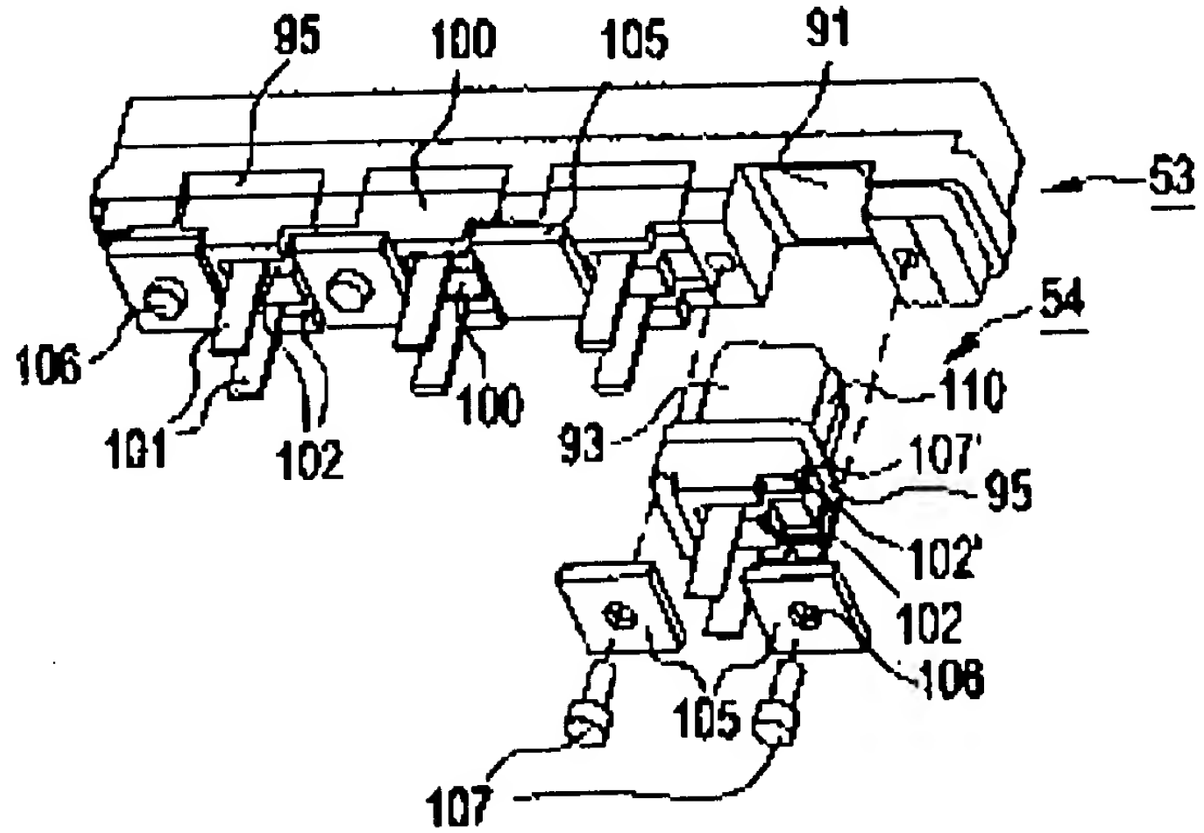


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FIG.18